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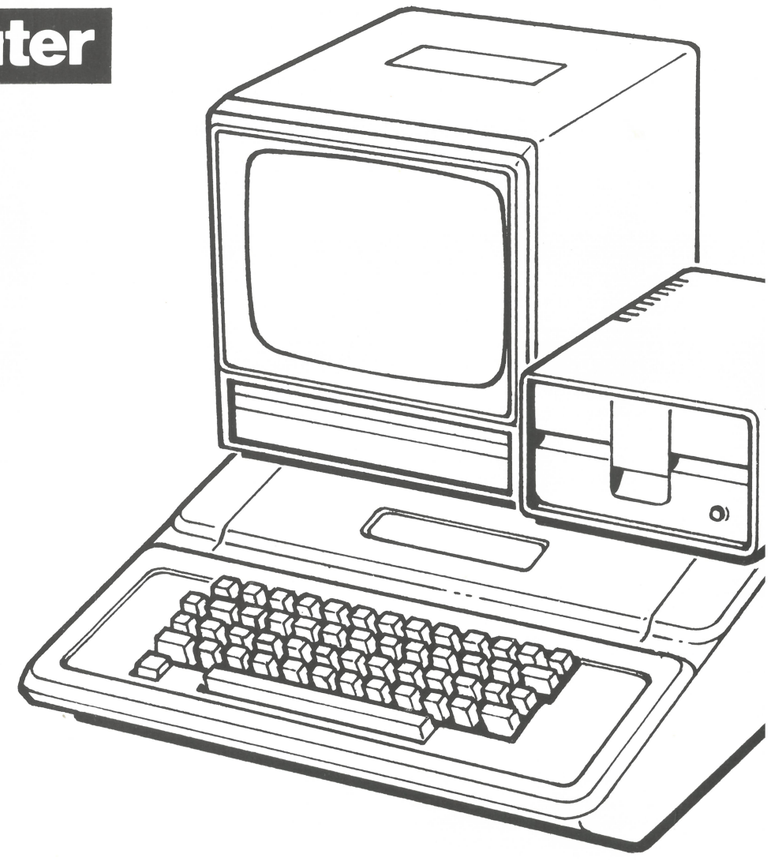

SOUND AND VIBRATIONS

STUDY GUIDE

by

Frank R. Salamon
Wesleyan University
Middletown, Connecticut

Co-Author
Addison Wesley Science Series

NEW ADDRESS
E.M.E
Old Mill Plain Rd.
Post Office Box 2805
Danbury, CT 06813-2805

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OVERVIEW

The E.M.E SOUND AND VIBRATIONS program provides elementary students with an introduction to the nature of sound energy. The program consists of two parts:

1. Explanation -- includes two sections: (1) How sounds are produced, vibration, frequency and pitch; (2) How sound travels and reflected sounds. A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of 15 randomly-selected questions to test student understanding of vibration, frequency, pitch, intensity and sources of sound. A short explanation is provided if a question is incorrectly answered. Quiz score is given at the end.

After students study the Explanation sections of the program, they will have a clear understanding of how sounds are produced and how they travel. This background will help them solve the problems found in the Quiz portion of the program.

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OBJECTIVES

The following concepts are developed in the program:

1. Sound is caused by vibrations.

2. Sounds travel in all directions from their point of origin.

3. The pitch of a sound is determined by the vibration rate (frequency) of whatever produces the sound.

4. Sounds travel through gases, liquids and solids but not through space or a vacuum.

5. Sound may be reflected; an echo is produced by reflected sound.

6. Humans can recognize sounds over a wide range of frequencies.

After using this program students will be able to:

1. Observe that sounds are created by objects that vibrate.

2. Recognize that vibration is a rhythmic back and forth movement of an object.

3. Show how vibrations affect the strength of sound.

4. Explain how the frequency of vibration relates to the pitch of sounds.

5. Test different materials for their ability to conduct sound.

6. Prove that sounds travel in all directions from their source.

USING THE PROGRAM

The E.M.E SOUND AND VIBRATIONS program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that students start with the Explanation sections. These provide students with the background needed to understand sound and to answer the quiz. The program is designed for Grades 4 and up.

You may wish to assign one student who has taken the quiz as your representative at the computer to record for you the scores of other students who take the quiz. The SOUND AND VIBRATIONS Quiz may also be used as an evaluation instrument by teachers who have completed a unit on this topic.

BACKGROUND

Sounds are so much a part of our lives that we often fail to notice them. Have students list the sounds they hear while sitting at their desks and describe them as soft or loud, high or low, pleasant or unpleasant, or using other descriptions of their choice. Point out the importance of sounds in bringing messages -- the blare of a car's horn, the crash of thunder, a bird's song and a church bell. Sound is one of the most important ways of communicating with others.

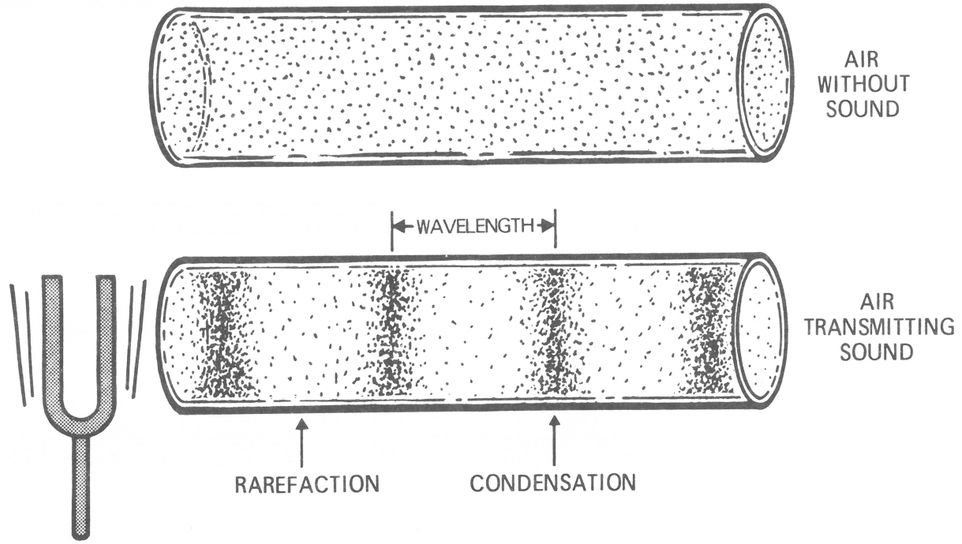
All sounds are produced by vibrations. These rhythmic back and forth movements cause waves that can move through solids, liquids and gases. Vibrations which can be detected by humans or animals are called sounds.

Stretch a rubber band between your fingers and pluck it. It will produce a sound.

Observe the back and forth motions of the rubber band. These are the vibrations which produce sound. When these vibrations stop, the sound stops.

Frequency is the measure of how many times an object is vibrating in a unit of time. The faster the object is vibrating, the higher the frequency. Frequency and pitch are directly related. As frequency increases, the sound that is produced has a higher pitch. Humans can hear frequencies ranging from about 20 to 20,000 vibrations per second. It is believed that some insects and other animals hear sounds humans cannot. There are whistles which produce high-pitched sound that dogs can hear but humans cannot. The SI (metric) unit Hertz (symbol Hz) is used to express frequency in vibrations (cycles) per second.

For a simplified description of sound waves, consider a tuning fork vibrating at one end of an open tube.



As the tip of the tuning fork moves outward, it pushes some air molecules to the right. They collide with other molecules to form an area, called a condensation, where molecules are tightly bunched. As the tip of the tuning fork moves to the left, air molecules flow into the space and form an area, called a rarefaction,

where the molecules are more widely separated. As the tuning fork continues its motion, sound vibrations -- a series of condensations and rarefactions -- travel away from it along the tube. This type of wave is called a compressional or longitudinal wave. In this type of wave the displacement of the particles of the medium is parallel to the direction in which the waves advance.

The distance between two adjacent areas of compression is called the wavelength. This is a measure of the pitch of the sound. Sounds with a low pitch have a long wavelength; those with a high pitch have a short wavelength. The maximum displacement of a molecule from its original position is the amplitude which is the primary factor affecting the loudness of the sound.

Sound waves move out in all directions from the source. If the source is a bell, it can be heard everywhere in a room -- near the floor and close to the ceiling. If a door is open, the sound may also travel out of the room and around corners.

In order for sound to travel the vibrations must have a carrier. The carrier may be any solid, liquid or a gas. Sound cannot travel across empty space. Because of this, there are no sounds on the moon or in outer space.

When we say that sound is traveling through the air (a gas), we mean that an energy wave called a "sound wave" is moving through the air. The particles of air set in motion by the vibrating source travel to your eardrum. The farther away you are from the source of the sound, the softer the sound becomes.

Sound waves also travel through water and other liquids. Have each student place an ear against the side of an aquarium filled with water while another strikes two stones under the water. The listener should be able to hear clearly the sound made by the stones. If possible, have your students do this experiment in a swimming pool.

Solids can also conduct sound waves. Have one student place an ear against one end

of a long table while another lightly taps the other end of the table with a pen or ruler. The student who is listening will hear the tapping clearly.

Does sound travel better through wood or air? Obtain a watch with a low but audible tick. Pick a student to listen to the ticking. Move the ticking watch away from the student's ear until the ticking cannot be heard. Next, touch one end of a meterstick to the student's ear and rest the stick against the watch. Can the student hear the ticking now? (The student should hear the ticking.) Move the watch to the end of the meterstick keeping the other end touching the student's ear. Will the ticking still be heard? (Yes.)

The speed of sound depends upon the medium through which it travels. In general, sound travels faster in solids and liquids than in air. At normal pressure and temperature, the speed of sound is about:

5,100 meters/second in steel
1,500 meters/second in water
340 meters/second in air

Compared with the speed of light, sound travels very slowly. Students may recall that there is often an interval of several seconds between the time they see a lightning flash and the time they hear the sound of the corresponding thunderclap.

Have you ever heard your voice come back to you as an echo from a building, cliff or hill? You hear your voice because sound bounces off certain surfaces, similar to the way a ball bounces off a wall. An echo is produced by a sound reflection. To hear an echo, you must be at least 16.75 meters away from the reflecting surface, otherwise the original sound and the reflected sound come so close together they cannot be distinguished.

There are times when it is necessary to concentrate sound waves to increase their audibility. One way to do this is to make a megaphone similar to those used by cheerleaders at sporting events. When a megaphone is used, the sound energy is concentrated rather than spread out over a wide space. You can make a megaphone

by rolling a piece of drawing paper into the shape of an open-ended cone.

Although the E.M.E SOUND AND VIBRATIONS program does not cover how humans hear, a brief description is useful. Our ears receive sound waves and convert them into nerve impulses. The ear consists basically of three parts: the outer ear, the middle ear and the inner ear. The outer ear collects vibrations. The middle ear changes the vibrations to nerve messages which are passed to the brain. Ask a student to research the topic "How We Hear" and report to the class.

ACTIVITIES

A tuning fork will be needed for these activities.

Strike a tuning fork on a solid object. This will cause the fork to vibrate. Hold it in the air over one end of a table. Place some children at the other end and ask if they can hear the tuning fork. Most will not be able to. Ask the children to figure out a way of hearing the tuning fork at a distance. One way is to set the stem of the vibrating tuning fork on the table and have them place an ear against the table. They should be able to hear the tuning fork as the sound travels through the table. Allow students to experiment with the vibrating tuning fork to find out what materials are good conductors of sound. Try sweaters, glass, rulers, neckties and long pieces of metal. Place the stem of a vibrating tuning fork on these materials and hold the other end of the object to another student's ear. (Sweaters and neckties are poor conductors; rulers, glass and metals are good conductors.)

Ask the music teacher to bring some musical instruments to your classroom and show the students how each one produces sounds. Try to display stringed, brass, keyboard, percussion and woodwind instruments. Also, have students make stringed instruments by stretching rubber bands of various widths across a small box. By plucking the bands, the students can discover much about sound. What happens when the rubber band is tightened? (The pitch goes up.) If a piano is available ask students to figure out how it produces sound and why some notes are high and others low. Create

a bulletin board of "Sounds We Like" and "Sounds We Do Not Like". The students may make drawings or cut our pictures from magazines which depict sounds they like or dislike.

Invite the school nurse or a doctor to your class to talk about how the ear functions and the proper procedures for good ear care. Make certain you have a large model or picture of the human ear for this activity.

A related topic that students may explore is the use of ultrasonics to chart the ocean floor, to detect flaws in metals, to clean teeth and for other medical, scientific and commercial uses.

STUDENT WORKSHEET ANSWERS

Worksheet I

1. T
2. T
3. F
4. F
5. T
6. T
7. F
8. T
9. F
10. T

Worksheet II

1. pitch
2. vibrate
3. directions
4. matter
5. echo
6. source
7. loudness
8. shorter
9. spread out
10. empty space

This program uses a high-speed operating system called
Diversi - DOS (tm) under license. For information
contact DSR, Inc., 34880 Bunker Hill, Farmington MI 48018.

GLOSSARY

amplitude: In a wave, how far a particle moves from rest to its maximum displacement.

compression: A region of high pressure in a wave such as a sound wave.

frequency: The rate at which an object is vibrating: the higher the rate, the higher the frequency.

pitch: How high or low a sound is: the higher the sound, the higher the pitch.

rarefaction: A region of minimum pressure in a wave such as a sound wave.

source: Matter which vibrates and produces sound.

ultrasonic: Having a frequency greater than the maximum audible to the human ear, 20,000 vibrations per second.

vibration: A rhythmic back-and-forth movement in an object.

wave: A vibration that travels along the surface of a liquid or through a solid, liquid or gas.

RESOURCES

Books

Branley, Franklyn M.: HIGH SOUNDS, LOW SOUNDS, Thomas Y. Crowell, New York, 1975.

Heuer, Kenneth: THUNDER, SINGING SANDS, AND OTHER WONDERS: SOUNDS IN THE ATMOSPHERE, Dodd, Mead, New York, 1981.

Kavaler, Lucy: THE DANGERS OF NOISE, Thomas Y. Crowell, New York, 1978.

Knight, David C.: SILENT SOUND: THE WORLD OF ULTRASONICS, Morrow, New York, 1980.

Thomas, Anthony: THINGS WE HEAR, Franklin Watts, New York, 1976.

Films

SOUNDS ALL ABOUT US, Coronet, Chicago, IL (11 minutes)

SOUNDS AROUND US, Cenco Education Films, Chicago, IL (10 minutes)

SOUNDS -- HOW THEY TRAVEL, Academy Films, Hollywood, CA (11 minutes)

SOUND WAVES, Encyclopedia Britannica, Chicago, IL (16 minutes)

SOUND WAVES AND THEIR SOURCES, Encyclopedia Britannica, Chicago, IL (16 minutes)

Name_____ Student Worksheet I

SOUND AND VIBRATIONS

True or False. Circle the T if you think the answer is true. Circle the F if you think the answer is false.

1. T F Sounds are caused by objects that vibrate or move back and forth quickly.
2. T F The pitch of a sound depends on how rapidly the source vibrates.
3. T F The frequency of a vibrating object does not depend on its length.
4. T F Sound cannot travel around corners.
5. T F Sound energy is picked up by a person's ears.
6. T F The loudness of sound depends on how close you are to its source.
7. T F Humans can hear sounds that dogs cannot.
8. T F Sound can travel through water, air, metal, plastic and wood.
9. T F A person swimming under water can hear no sounds.
10. T F An echo is a sound reflected back to its source.

Name_____ Student Worksheet II

SOUND AND VIBRATIONS

Use the words listed below to fill in the blanks in the sentences.

brain	shorter	vibrate	loudness	directions
pitch	echo	matter	source	empty space
spread out				

1. A gym teacher's whistle has a higher_____than an auto horn.
2. Sounds are caused by things that_____quickly.
3. Most sounds move out in all_____from the source.
4. Sounds can travel through all_____.
5. Without a surface to reflect sound, there is no_____.
6. and 7. As a sound wave travels out from its_____there is a decrease in_____.
8. Making the vibrating part of a ruler_____causes its frequency to be greater.
9. A long, open tube carries sound well because sound cannot_____ in it.
10. Sound cannot travel through_____.

TEXTBOOK CORRELATION GUIDE

Addison Wesley Science	Book 4, Chapter 8
Coronado Science & Technology	Book 4, Unit 5, Chapter 15
Harcourt Brace Science	Book 2, Unit 6 Book 4, Unit 2, Chapters 1-5
Heath Science	Book 2, Unit 2, Chapter 2
Holt Elementary Science	Book 5, Unit 2, Chapters 4,5
Laidlaw Exploring Science	Book 3, Unit 4, Chapters 1,2 Book 6, Unit 4, Chapter 1
Merrill Accent on Science	Book 2, Chapter 2 Book 4, Unit 6, Chapters 1-3
Scott Foresman Science	Book 3, Chapter 4 Book 5, Chapter 14
Silver Burdett Science	Book 3, Unit 2, Chapter 8

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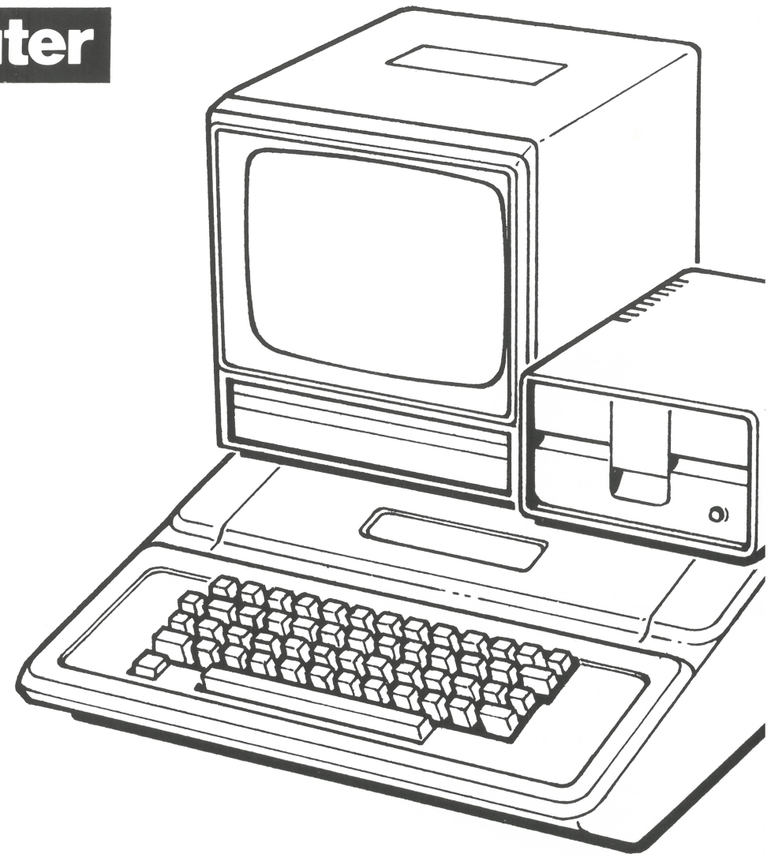

PHYSICAL OR CHEMICAL

STUDY GUIDE

by

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TEXTBOOK CORRELATION GUIDE

Addison Wesley Science	Book 5, Chapter 3
Coronado Science & Technology	Book 3, Unit 1, Chapters 1-2
Harcourt Brace Science	Book 3, Unit 4 Book 4, Unit 4, Chapter 2,3 Book 5, Unit 5, Chapters 1-3
Heath Science	Book 4, Unit 3, Chapter 4 Book 6, Unit 2, Chapter 5
Holt Elementary Science	Book 6, Unit 3, Chapters 7-9
Laidlaw Exploring Science	Book 4, Unit 4, Chapters 1-3 Book 6, Unit 3
Merrill Accent on Science	Book 3, Unit 3, Chapters 1-4 Book 5, Unit 2, Chapter 3 Book 6, Unit 2, Chapter 2
Scott Foresman Science	Book 5, Chapters 10,12
Silver Burdett Science	Book 3, Unit 2, Chapter 5 Book 4, Unit 2, Chapter 5 Book 5, Unit 2, Chapter 6 Book 6, Unit 2, Chapter 6

OVERVIEW

The E.M.E PHYSICAL OR CHEMICAL program will help middle and upper grade elementary students to understand the difference between physical and chemical properties and to distinguish physical from chemical changes. The program consists of two parts:

1. Explanation -- covers physical properties (mass, volume, state, color, luster, odor and taste) and physical changes of state. Defines chemical properties and shows how these determine the way in which one substance reacts with another. A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of 15 randomly-selected questions where the student identifies a change as physical or chemical. A short explanation is provided if a question is incorrectly answered. Quiz score is provided at the end.

The E.M.E PHYSICAL OR CHEMICAL program is copyrighted and may not be reproduced, stored in a retrieval system, or transmitted by any means without prior written permission from the publisher.

OBJECTIVES

The following concepts are developed in the program:

1. All matter occupies space and has mass.

2. Properties such as texture, color, odor, shape, hardness, lightness and heaviness are physical properties.

3. The three states of matter are solid, liquid and gas.

4. Matter changes from one state to another at certain temperatures.

5. A chemical change results in a new substance being formed.

6. Properties that describe the behavior of a substance reacting with other substances are called chemical properties.

After using this program students will be able to:

1. Recognize the physical properties of various objects and name the senses used to identify each property.

2. Identify and measure the properties of volume and mass.

3. Create and describe a physical change.

4. Identify the chemical properties of matter and describe a chemical change.

USING THE PROGRAM

The PHYSICAL OR CHEMICAL program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that students start with the Explanation section. This provides the background needed to understand physical and chemical changes and to answer the questions in Part 2. The program is designed for Grades 3 and up.

You may wish to assign a student who has taken the quiz as your representative at the computer to record the scores of other students who take the quiz. The Quiz section of PHYSICAL OR CHEMICAL may also be used as an evaluation instrument by teachers who have completed a unit on chemistry or changes in matter.

BACKGROUND INFORMATION

At ordinary temperatures, matter exists in three states: solid, liquid and gas. A fourth state or phase of matter, called plasma, exists at very high temperatures. Plasma exists inside stars, where temperatures are several thousand degrees Celsius. In this program we shall deal only with solids, liquids and gases.

A solid has a definite shape. Examples of solids include blocks of wood, magnets, copper pipes, ice, plastic containers, paper boxes and silverware. A liquid does not have a definite shape, but rather takes the shape of its container. The most familiar liquid is water. Other liquids include oil and mercury. Like a liquid, a gas has no definite shape. The air we breathe is a mixture of several gases with nitrogen the most abundant and oxygen next. There are also small amounts of carbon dioxide, water vapor and other gases present in air. Helium and hydrogen are other gases your students may know.

All matter, whether solid, liquid or gas, has two physical properties in common -- it takes up space and has mass. The amount of space a substance occupies is called its volume. A good example to discuss with students is air. An "empty" open container is filled with air. When anything is put into the container, air is displaced. Try this: fill a plastic sandwich bag with air. Place the air-filled bag over the mouth of a large jar and secure it tightly with a rubber band. Try to push the bag into the jar. The bag will not go into the jar because both are filled with air. If you pull the rubber band slightly away from the jar and then push on the bag, it will go into the jar because the air has a way to escape. You will be able to feel the air escape at the point you are holding the rubber band.

Mass is the amount of matter in something. The mass of any object depends on the kind of matter of which it is made. A cubic meter of wood and a cubic meter of iron occupy the same volume but the iron's mass is much greater. Generally, larger objects have a greater mass than smaller objects. However, a bowling ball has more mass than a basketball even though the basketball has a greater volume. Two objects have the same mass if they balance each other on an equal-arm balance.

The physical properties of matter can be observed with your senses. (Safety note -- caution your students never to taste or directly smell materials.) Have the students list the senses employed in studying the physical properties of different kinds of matter. Their list may include:

seeing: color, shape

touching or feeling: soft, hard, rough, smooth, light, heavy

tasting: sweet, sour, bitter

smelling: has no odor, smells sweet, awful

Have the students make up a list of properties of sugar and salt that they can observe using only their senses.

Physical changes involve changes in form or state. If a student bends wire, changes the shape of a lump of clay or freezes water, the chemical composition of the substance is not changed. Since no new substance was created, the changes in the wire, clay and water are called physical changes.

A property that tells how one substance reacts with another to form a new substance is a chemical property. When one or more new substances are formed, a chemical reaction has occurred. The new substance(s) will have physical and chemical properties different from those of the original substance(s).

The rusting of iron is an example of a chemical reaction. Iron is metallic and strong. When it is exposed to oxygen it is changed to a brittle, reddish material called iron oxide, also known as rust. The ability of iron to combine with oxygen to form a new substance is a chemical property.

Other metals such as magnesium and aluminum also combine with oxygen to form new substances. Thus, most metals are said to have similar chemical properties. Other substances that can be grouped by similar chemical properties include acids, bases, salts, sugars and alcohols.

STUDENT ACTIVITIES

1. Changing state: most students are familiar with water in its three different states -- ice, water and water vapor. Set up an "ice cube race" with each student given an ice cube, a cup and paper towels or newspaper. The object is to melt the ice cube as quickly as possible. Do not allow students to place the ice cube in their mouths. This activity can also be done with the objective of keeping the ice cube from melting for as long as possible.

2. Chemical reactions: Place a piece of wet steel wool in a jar and cover it. Check an hour later and a day later. Ask students for possible explanations.

TEACHER DEMONSTRATION

Obtain small, thin samples of magnesium ribbon, zinc, iron (steel wool), copper and tin. CAUTION: Use safety goggles and do not look directly at burning magnesium. Hold each piece of metal with forceps over a Bunsen burner placed on a fireproof surface.

Have students record the physical properties of each metal before and after burning. Also have them list the metals in order from easiest to burn to hardest to burn.

GLOSSARY

chemical change - a change that results in making one or more new substances.

chemical property - a characteristic that tells how a substance reacts with one or more substances to form one or more new substances.

gas - a state of matter in which a substance expands to fill a closed container.

liquid - a state of matter in which a substance assumes the shape of an open container.

physical change - a change in form or shape.

physical property - a characteristic of a substance which can be observed by one's senses.

solid - a state of matter in which a substance has a definite shape and volume.

volume - the amount of space occupied by a substance.

RESOURCES

Ardley, N.: ATOMS AND ENERGY, Franklin Watts, New York 1976.

Asimov I.: BUILDING BLOCKS OF THE UNIVERSE, Abelard-Schuman, New York 1974.

Bendick, J.: SOLIDS, LIQUIDS AND GASES, Franklin Watts, New York 1974.

Srivastara, J.: SPACES, SHAPES AND SIZES, Crowell, New York 1980.

FILMS

"A Look at Chemical Change," Mc-Graw-Hill, New York (15 minutes).

"Chemical Change All About Us," Coronet, Chicago (14 minutes).

"Matter, Matter Everwhere, How Materials Change," Coronet, Chicago (11 minutes).

This program uses a high-speed operating system called Diversi - DOS (tm) under license. For information contact DSR, Inc., 34880 Bunker Hill, Farmington MI 48018

STUDENT WORKSHEET ANSWERS

1.	A	chemical	F	physical	2.	A	physical	F	chemical
	B	chemical	G	physical		B	chemical	G	physical
	C	solid,liquid,gas	H	space		C	physical	H	physical
	D	mass	I	physical		D	chemical	I	physical
	E	chemical	J	physical		E	physical	J	chemical

Student Worksheet

Name_____

PHYSICAL OR CHEMICAL

1. Fill in the blank with the word that makes the statement correct.

   A. Properties that describe the way substances react with other substances are called_____properties.

   B. When vinegar and baking soda are mixed, carbon dioxide (CO_2) is produced. This mixing is an example of a_____change.

   C. Three states of matter are_____, _____ and_____.

   D. _____is the amount of matter in something.

   E. Changes which produce new substances are called _____changes.

   F. When water boils a_____change takes place.

   G. Color is an example of a_____property.

   H. Volume is the amount of_____something takes up.

   I. A change in the shape of a material is called a_____change.

   J. The_____properties of matter may be observed by the senses.

2. Write the word physical or chemical in the blank.

   A. Cutting a piece of wood is a_____change.

   B. Metal that is rusting is undergoing a_____change.

   C. Stretching a wire is a_____change.

   D. Baking a cake produces_____changes.

   E. Freezing water to ice is a_____change.

   F. Heating small pieces of wood in a test tube over a gas burner produces a _____change.

   G. Breaking a piece of clay into two pieces is a _____change.

   H. Stretching a rubber band is a_____change.

   I. Mixing table salt and water is a _____change.

   J. A candle burning is a _____change.

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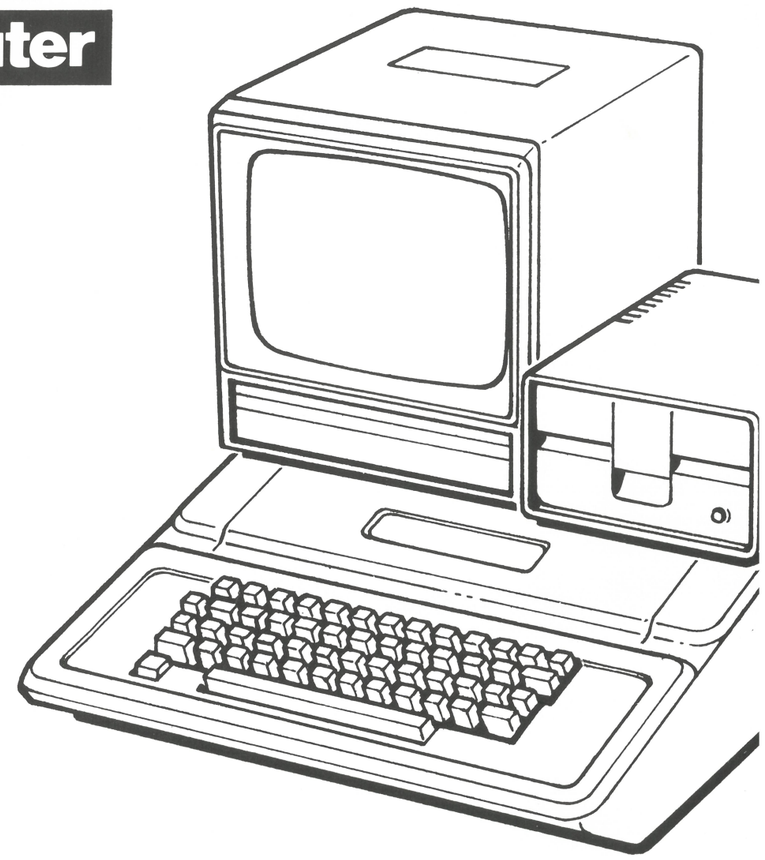

SHADOWS AND LIGHT

STUDY GUIDE

by

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Old Mill Plain Rd.
Post Office Box 2805
Danbury, CT 06813-2805

OVERVIEW

The E.M.E SHADOWS AND LIGHT program provides elementary students with an introduction to the basics of light by emphasizing how shadows are formed. The program consists of two parts:

1. Explanation -- illustrates how a light source and objects create shadows and reflect light. Also explains the terms opaque, transparent and translucent. A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of 20 randomly-selected questions where students identify the shadows of different blocks placed in various positions and at different distances from a light source. Quiz score is provided at the end.

After students study the Explanation section of the program, they will be ready to experiment with shadows and light on their own and solve the problems in the Quiz portion of the program.

The E.M.E SHADOWS AND LIGHT program is copyrighted and may not be reproduced, stored in a retrieval system or transmitted by any means without prior written permission from the publisher.

OBJECTIVES

The following concepts are developed in the program:

1. The requirements to create a shadow are: a light source, an object to block the light and a surface on which the shadow can fall.

2. The sun, other stars, electric lights, flashlights and fire are sources of light.

3. Most objects reflect light. The moon, mirrors and other objects reflect light that strikes them. They are not light sources.

4. Shadows can be created by light from direct sources and by reflected light.

5. Shadows can be cast by objects that are translucent and opaque. Generally, the opaque object will cast the darker shadow.

6. A single object may cast shadows of more than one shape.

7. By moving the object, or the light or the screen, one can change the size and shape of the shadow.

After using the program the students will be able to:

1. Determine which objects reflect light and which are light sources.

2. Classify materials as opaque, transparent or translucent.

3. Predict the different shadows an object can cast.

4. Discover an object that can cast only one shape of shadow.

5. Predict how moving an object toward the light or toward the screen will change the size and shape of the object's shadow.

USING THE PROGRAM

The SHADOWS AND LIGHT program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that students start with the Explanation section. This provides the background needed to understand shadows and light and to answer the questions in Part 2. The program is designed for Grades 2 and up.

You may wish to assign one student who has taken the quiz as your representative at the computer to record for you the scores of other students who take the quiz. The SHADOWS AND LIGHT Quiz may also be used as an evaluation instrument by teachers who have completed a unit on this topic.

BACKGROUND

Anything that can produce light is called a light source. Examples are the sun, other stars, electric light and burning substances.

The majority of objects we see do not produce light but rather reflect light produced by a light source. For example, the moon reflects the sun's light. Mirrors and shiny objects are good reflectors. When light strikes an object it may pass through the object, be reflected or be absorbed. At times there is a combination of all three.

Anything you can see is capable of casting a shadow. Objects that are opaque cast the darkest shadows. Transparent substances allow some light through and thus cast lighter shadows than opaque objects. Transparent objects, which allow almost all of the light through, cast the lightest shadows. A clear plastic sandwich bag will cast a shadow as

will a clear glass tumbler. Water placed in the tumbler will cast a deeper shadow. If you use a straw to blow air into the water, you will find that bubbles in the water will cast shadows.

One object can cast different shadows depending on its position in relation to the light. A book, for example, will cast these shadows with light striking its:

front cover

spine

top

Shadows from a sphere are unique in one way. For a given arrangement of light source, sphere and screen, the sphere's shadow stays the same however the sphere is rotated. Curved objects can cast straight shadows and straight objects can cast curved shadows if you bend the screen on which they fall.

When an object between the light source and the screen is moved toward the light its shadow becomes larger. But as its shadow becomes larger, it also becomes fuzzier. Conversely, as an object moves toward the screen, its shadow becomes smaller and sharper.

ADDITIONAL ACTIVITIES

To perform experiments similar to those presented in the Quiz part of the program obtain a strong light source (large flashlight or filmstrip projector), various objects (balls, blocks, ruler, pencils, empty spools and tubes), and a screen (large sheet of white paper or white cloth). Set up the screen in front of the students (a sheet hung in a doorway works well). Place a light source behind the screen and hold objects between the screen and light source. The objects will cast shadows on the screen. Students cannot see the object but they can see its shadow. Ask them to guess what the object is by its shadow. (The shadow cast by a belt is challenging because it can be rolled up to cast a circular shadow, held on its side for a rectangle shape and unrolled to produce a long rectangle.)

During a sunny day, have students mark the top of a shadow cast by a vertical stake

or flagpole hour-by-hour through the school day. Ask students to explain the pattern found.

TEXTBOOK CORRELATION GUIDE

Addison Wesley Science	Book 3, Chapter 6
Coronado Science & Technology	Book 3, Unit 3, Chapter 9
Harcourt Brace Science	Book 2, Unit 5 Book 4, Unit 3, Chapters 1,2
Heath Science	Book 2, Unit 3, Chapter 4
Holt Elementary Science	Book 4, Unit 2, Chapter 2 Book 6, Unit 3, Chapter 7
Laidlaw Exploring Science	Book 1, Unit 4
Merrill Accent on Science	Book 2, Chapter 6 Book 4, Unit 2, Chapter 1
Scott Foresman Science	Book 3, Chapter 3
Silver Burdett Science	Book 2, Unit 8 Book 3, Unit 3, Chapters 1,2 Book 6, Unit 2, Chapter 7

GLOSSARY

cast: To form or create (a shadow).

light source: An object or device which can produce light.

opaque: Not allowing light to pass through.

reflect: To throw back (especially light) on being struck.

translucent: Allowing some light to pass, but not allowing objects beyond to be seen clearly.

transparent: Transmitting enough light so objects on the other side can be seen clearly.

RESOURCES

Gardner, Robert and Webster, David: SHADOW SCIENCE, Doubleday, Garden City, New York 1976.

Goor, Ron and Goor, Nancy: SHADOWS: HERE, THERE AND EVERYWHERE, Thomas Y. Crowell, New York, 1981.

Schneider, Herman: SCIENCE FUN WITH A FLASHLIGHT, McGraw-Hill, New York, 1975.

This program uses a high-speed operating system called Diversi - DOS (tm) under license. For information contact DSR, Inc., 34880 Bunker Hill, Farmington MI 48018.

Name_____

Student Worksheet

SHADOWS AND LIGHT

1. What three things are required to cast a shadow?

   A. B. and C.

2. Circle the light sources in the following list:

moon	sun	match	diamond
candle	window	mirror	telephone pole
gold	star	flashlight	electric light

3. Circle the correct answer.

   A. Which objects cast the darkest shadow?

      opaque translucent transparent?

   B. Which objects cast the lightest shadow?

      opaque translucent transparent

4. How can you make the shadow of an object larger?

5. Write the letter(s) of the objects under the shadows they can cast.

   A. baseball
   B. book
   C. can
   D. doughnut
   E. cube
   F. pyramid
   G. cone

6. During an eclipse of the moon the light source is_____, the object casting the shadow is_____and the screen is_____.

STUDENT WORKSHEET ANSWERS

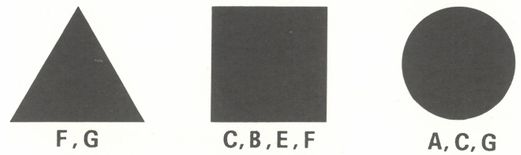
1. light source, object and screen

2. light sources: candle, sun, star, flashlight, match and electric light

3A. opaque 3B. transparent

4. Move the object closer to the light source.

5.



6. During an eclipse of the moon the light source is the sun, the object casting the shadow is the earth and the screen is the moon.

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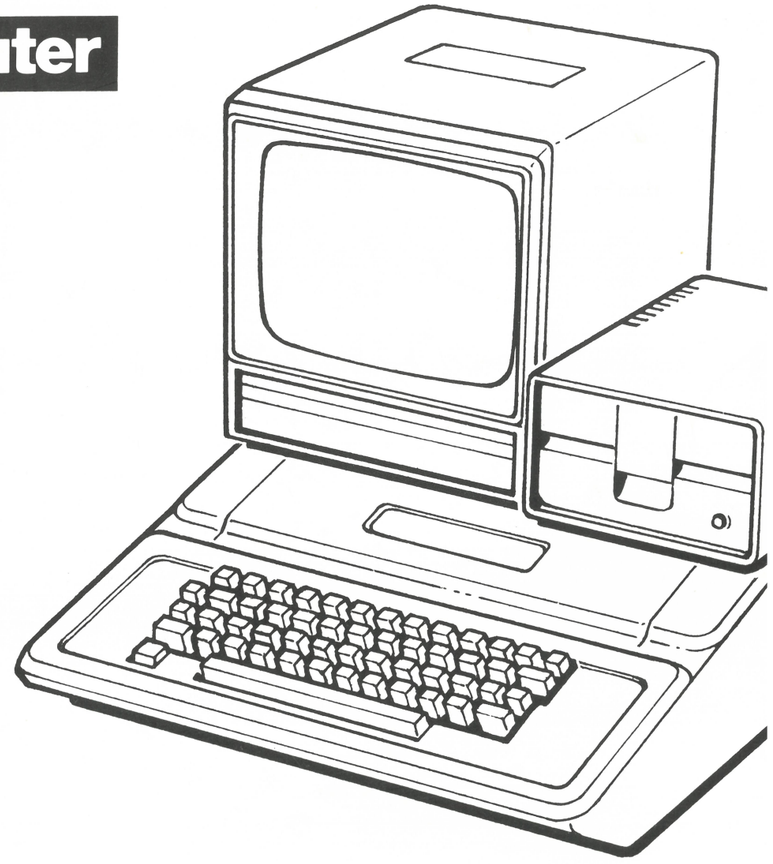

CLASSIFICATION

STUDY GUIDE

by

Frank R. Salamon
Wesleyan University
Middletown, Connecticut

Co-Author
Addison Wesley Science Series

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OVERVIEW

The E.M.E CLASSIFICATION OF OBJECTS program introduces lower and middle grade elementary students to the concept of classification. The program consists of two parts:

1. Explanation -- describes sorting into groups by one or two common characteristics such as shape, number of sides or number of dots. A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of 15 randomly-selected questions. Tests student understanding by having them check sets of five objects and identify the one that does not "belong". A short explanation is provided for incorrect answers. Quiz score is given at the end.

After your students study the Explanation section of the program, they will be ready to create classification systems of their own and to solve the problems in the Quiz portion of the program.

The E.M.E CLASSIFICATION OF OBJECTS program is copyrighted and may not be reproduced, stored in a retrieval system or transmitted by any means without prior written permission from the publisher.

OBJECTIVES

The following concepts are developed in the program:

1. Classification is based on sorting things into groups that share the same characteristics, for example, circles, squares, triangles or objects with the same number of sides or holes.

2. Objects with a given characteristic make up one group (all are triangles, plants, or animals).

3. A large group of objects can be divided into two or more smaller groups. For example, a group of triangles could be sorted into groups by color. Then each group could be subdivided into large and small triangles.

4. Knowing the characteristics of a group helps students to understand members of that group and can assist in identifying unknown objects.

After using the program the students will be able to:

1. Recognize similar and different characteristics of a group of objects.

2. Recognize that a group of similar objects may be divided into smaller groups.
3. Develop a system that classifies objects by one or two properties.
4. Use someone else's classification system to identify an object.

USING THE PROGRAM

The CLASSIFICATION OF OBJECTS program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that students start with the Explanation section. This portion provides the student with background information needed to understand classification and answer the quiz. The program is designed for Grades 2 and up.

You may wish to assign one student who has taken the quiz as your representative at the computer to record the scores of other students who take the quiz. The Quiz section of CLASSIFICATION OF OBJECTS may also be used as an evaluation instrument by teachers who have completed a unit on this topic. The program can also be used by students in the upper grades as an introduction to taxonomy, the classification of plants and animals.

BACKGROUND

Classification is the organizing of objects into groups that share one or more common characteristics or properties.

People arrange all kinds of things into groups. Dishes and silverware are organized into groups and places in the family kitchen or dining room. Libraries and supermarkets are excellent places to see classification systems in use. People are grouped according to their occupation -- auto mechanics, truck drivers, police, teachers, politicians, and so on. Foods can be classified as sweet, sour, bland or spicy. Materials to make clothes can be grouped by their texture such as rough, smooth, silky or fuzzy.

Classification is especially valuable in science for it brings order to a problem and enables us to find patterns or relationships helpful to understanding. For example, rocks may be classified according to their origin, elements by their chemical properties, plants according to whether or not they produce seeds and animals by those that have backbones and those without.

ADDITIONAL ACTIVITIES

You may wish to extend the concepts covered in the program by introducing more shapes or shapes made of different colored papers. Use red, green, blue and yellow circles, squares, triangles and other geometric shapes.

Other activities for students include the following:

1. Classifying animals into groups that fly, swim, crawl, walk, creep or hop. For the younger student it would be wise to have pictures of animals cut from old magazines available so they could place them in the proper group.
2. Children enjoy building classification systems using buttons. They are excellent objects to classify because they have many different characteristics. Some have two holes, others four. Buttons can be made from wood, metal, glass, plastic, shells or leather. Some are round, others square and they come in many different colors. This activity develops the concept that within a group of objects there are differences.
3. Another activity that involves children in building classification systems is using seeds they have collected from foods they have eaten. Which of these seeds come from plants considered trees (apple, peach)? Which come from plants not considered trees (beans, pumpkin, cucumber, squash)? This activity can be extended by having the children bring in pictures of foods that grow above the ground (pears, lettuce, berries, cabbage, peppers) and those that grow below the ground (beets, carrots, peanuts, radishes, potatoes).
4. Collect different kinds of leaves including leaves from different varieties of oak or maple trees. This introduces the concept of multi-level classification.
5. Have students read and describe how the following library books use classification:

   Elswit, Sharon: ANIMAL HOMES, Golden Books, New York, 1984

   Sattler, H.: DINOSAURS OF NORTH AMERICA, Lothrop, Lee & Shepard, New York, 1981

   Selsam, M. and Hunt, J.: A FIRST LOOK AT BIRDS NESTS, Walker, New York, 1984

GLOSSARY

characteristic, attribute, trait: A property or distinguishing quality such as tall, heavy or red.

classification: A system developed by sorting into groups with common characteristics.

sort: To place in a specific group or separate from others that differ.

taxonomy: A classification system especially of plants and animals.

TEXTBOOK CORRELATION GUIDE

Addison Wesley Science	Book 2, Chapters 2,10 Book 5, Chapter 1
Coronado Science & Technology	Book 2, Unit 5 Book 4, Unit 4, Chapters 11-13
Harcourt Brace Science	Book 1, Units 2,3,6 Book 2, Units 1,2,5
Heath Science	Book 1, Unit 2
Holt Elementary Science	Book 2, Unit 5, Chapters 1-6
Laidlaw Exploring Science	Book 1, Unit 2 Book 2, Unit 2
Merrill Accent on Science	Book 1, Chapter 2 Book 2, Chapter 1 Book 3, Unit 1, Chapter 1 Book 4, Unit 4, Chapter 2 Book 5, Unit 1, Chapters 1,2
Scott Foresman Science	Book 1, Chapter 6 Book 2, Chapter 3 Book 5, Chapter 1
Silver Burdett Science	Book 1, Chapters 1-5 Book 2, Unit 4 Book 3, Unit 1, Chapter 4 Book 4, Unit 1, Chapter 2 Book 5, Unit 1, Chapters 2,3

Name_____ Student Worksheet

CLASSIFICATION

1. Circle the object that does not belong in each group.

A.

B.

C. APPLE SPINACH TOMATO PEAR

D. BOOK PEN CRAYON PENCIL

2. Sort these items into two groups. What name would you give to each group?

dog	rose	fish	peach
eagle	whale	orange	grass
tree	turtle	gerbil	elephant

Group 1 Name_____ Group 2 Name_____

3. Classify these animals according to the most important way they move. Fill in chart.

butterfly	tiger	snail
turtle	bee	cat
snake	trout	robin
worm	eel	whale

SWIM	CRAWL	WALK OR RUN	FLY

4. Some animals have backbones -- these animals are called vertebrates. Animals without backbones are called invertebrates. List each animal under in its correct class.

goat	sponge	dog
bee	dinosaur	worm
rabbit	bluebird	fly
frog	shark	lobster

VERTEBRATE	INVERTEBRATE

STUDENT WORKSHEET ANSWERS

1. A rectangle (only four-sided figure)

   B hexagon (only shape without a dot)

   C spinach (only non-fruit)

   D book (only non-writing instrument)

2. Animals: dog, eagle, elephant, turtle, fish, gerbil, whale

   Plants: tree, rose, orange, peach, grass

3.

SWIM	CRAWL	WALK OR RUN	FLY
trout	snake	tiger	butterfly
eel	snail	cat	robin
whale	worm	turtle	bee

4.

VERTEBRATES	INVERTEBRATES
goat	bee
rabbit	sponge
dinosaur	worm
bluebird	fly
dog	lobster
shark	frog

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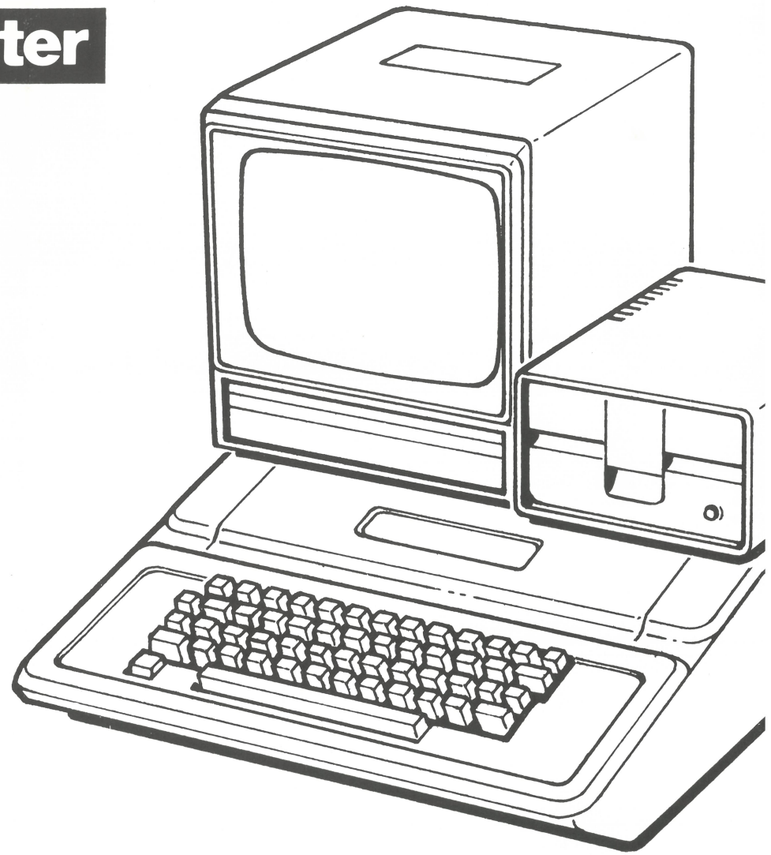

WATER IN THE AIR

STUDY GUIDE

by

Frank R. Salamon
Wesleyan University
Middletown, Connecticut

Co-Author
Addison Wesley Science Series

EDUCATIONAL
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ENT COMPANY
0803

NEW ADDRESS
E.M.E
Old Mill Plain Rd.
Post Office Box 2805
Danbury, CT 06813-2805

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OVERVIEW

The E.M.E WATER IN THE AIR program will help upper-elementary and middle school students solve problems dealing with water in the atmosphere. The program consists of two parts:

1. Explanations -- (a) evaporation, condensation and sublimation
   (b) light and heavy molecules
   (c) sources of water vapor

   A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of 25 randomly-selected questions where the student solves problems dealing with evaporation, condensation, sublimation and transpiration. A short explanation is provided if a question is incorrectly answered. The student's score is given at the end.

The E.M.E WATER IN THE AIR program is copyrighted and may not be reproduced, stored in a retrieval system, or transmitted by any means without prior written permission from the publisher.

OBJECTIVES

The following concepts are developed in the program:

1. Matter exists as solids, liquids and gases.
2. Normally as energy is added, a solid changes to a liquid then to a gas. As energy is removed the normal sequence is gas to liquid to solid. However, some solids can change directly to a gas and some gases can change directly to solids without becoming liquids.
3. Energy is required to evaporate a liquid. The rate of evaporation increases as the level of heat energy is increased.
4. The energy for evaporation comes from outside the evaporating matter.
5. An increase in surface area results in an increase in the rate of evaporation.
6. When loss of energy in water vapor reaches a certain point condensation occurs.
7. Water vapor does not carry any dissolved substances in it.
8. Gases in containers of equal size, at the same temperature and pressure hold the same number of molecules.
9. Seventy percent (70%) of the earth's surface is covered by oceans; most of the water vapor in the air comes from the oceans.
10. Leaves of green plants, the breathing of humans and animals, and the burning of fuels are other sources of water vapor.
11. A specific volume of dry air is heavier than the same volume of moist air.

12. The principal processes involved in the water cycle are evaporation and condensation.

After using this program the student will be able to:

1. define evaporation, condensation, transpiration, water vapor and sublimation.
2. explain the water cycle and identify sources of water vapor.
3. design an experiment showing that evaporation leaves dissolved substances behind.
4. understand why things cool when water evaporates from them.
5. state whether energy is lost or gained by evaporation and condensation.
6. determine which is heavier, a certain volume of dry air or the same volume of moist air.
7. design an experiment which shows that a larger surface area results in a faster rate of evaporation.
8. explain the process of condensation and design an experiment which shows condensation.

USING THE PROGRAM

The E.M.E WATER IN THE AIR program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that you start with the Explanation section. This provides the student with background needed to understand water in the atmosphere and to answer the questions in the Quiz. This program is designed for grades 5 and up.

You may wish to assign one student who has taken the quiz as your representative at the computer to record the scores of other students who take the quiz. WATER IN THE AIR may also be used as an evaluation instrument by teachers who have completed a unit on the topic of weather.

BACKGROUND

Much of our weather is caused by water in the air. To understand what causes rain, snow, humidity and cloudiness, it is essential to understand evaporation, the principal process by which water enters the air. Evaporation requires energy. The more energy absorbed by a liquid the faster the rate of evaporation.

To show the effect of temperature on evaporation, have students put equal amounts of water into two identical containers. Heat one container over a hot plate or other heat source. Leave the other container at room temperature. Ask the students to predict the outcome of this experiment. The heated container will have a faster rate of evaporation than the one left at room temperature.

Another way of showing the effect of heat on evaporation is to put equal amounts of water in similar containers (TV dinner trays work well). Place one tray in a sunny place and the other in shade. After 24 hours have students measure the remaining water and compare results. The tray in the sun should have less water left.

When energy is absorbed by water, some of the water molecules leave the liquid and mix with air. This invisible form of water is known as water vapor. Wind speeds the evaporation process, as anyone knows who has hung clothes on a line to dry. Wet clothes dry faster on sunny and windy days rather than sunny calm days.

An experiment in class will verify this. Wet two pieces of cloth, same size and material; two handkerchiefs work well. Place both on a line in a sunny place some distance apart. Direct the air flow from a room fan onto one of the handkerchiefs. You will find that the one in the path of the airflow dries much faster.

To demonstrate the effect of wind on a wet surface, wet two spots on the class chalkboard. Fan one wet spot with a piece of cardboard or book. Do not fan the other spot. Students will observe that the spot which was fanned disappears (evaporates) more quickly than the unfanned spot.

Water Cycle

The sun is the energy source behind the movement of water, from sea to sky to land and to sea again. This pathway is called the water or hydrologic cycle.

The water cycle begins at sea. Here water molecules at the surface, heated by the sun, change from a liquid to a gas and escape into the atmosphere. Millions of

metric tons of water are evaporated from the world's oceans every second. Although water evaporation occurs anywhere on the earth's surface, the oceans account for 80% of the total. As evaporation takes place, tremendous amounts of heat are absorbed by the oceans from the atmosphere. Thus, the water cycle has a powerful influence on climate.

Because water vapor is colorless, it flows invisibly through the atmosphere. Carried by the winds, it sweeps over the continents. Wherever the flow encounters cooler air, tiny water droplets form and become visible as clouds. The appearance of clouds marks the next step in the cycle -- the change of water from vapor to liquid again -- called condensation. Not all clouds are liquid, for in extremely cold air the droplets freeze to become tiny ice crystals. Cirrus clouds are an example of "ice clouds".

In a dense cloud the water droplets are constantly colliding and joining to form larger and larger drops. Soon even the strongest winds cannot keep them aloft. They fall as precipitation, bringing the ocean's water, now fresh, to even the highest mountains. The precipitation may be in the form of rain, sleet, hail or snow depending on the temperature.

On the surface, heavy rains fill the soil and tiny rivulets appear. These trickle across the land finding their way to streams and rivers on their journey back to the ocean. If you were to follow a water molecule in its many trips through the water cycle you would find on average it spends about 98% of its time in the ocean. About 1½% of the time it would be locked in glacial ice, and the remaining ½% in lakes, rivers and the atmosphere.

Plants and trees are another significant source of atmospheric water vapor. They draw large amounts of water through their roots to their leaves. After useful minerals are withdrawn most of the water escapes from the leaves as water vapor. This process is called transpiration.

The burning of fuels also contributes water vapor to the atmosphere. Often you can see the white trail of a jet as it flies overhead. Part of this trail is water vapor, as is the exhaust from an automobile on a cold day. Breath and perspiration from people and animals are also sources of water vapor.

To illustrate condensation, use an aluminum pan or metal measuring cup and some ice cubes. Mix the water and ice cubes in the container. After a few minutes, droplets of water will form on the outside of the container. Allow students to speculate about the source of these droplets. If some think the container leaked, suggest they add food coloring to the water in the container to see if the droplets on the outside become colored.

To confirm this, fill a similar pan or cup with hot water. Do droplets form on the outside of this container? No, droplets do not form on the pan with hot water. Therefore, it is reasonable to conclude that the water droplets come from water vapor in the air. Another example of condensation is when we exhale and "see" our breath on a cold day.

Sublimation is change directly from a solid to a gas without going through the liquid state. An example of this process is the dry ice (solid carbon dioxide) used as a coolant. During hot weather dry ice does not melt, it just seems to disappear. The solid carbon dioxide changes directly to a gas as heat is absorbed. Solid forms of water such as ice and snow also will sublimate. In areas that have cold and clear winter days, snow banks slowly contract without melting. The missing snow has changed directly to water vapor.

The term sublimation is sometimes applied to the reverse process -- that of changing from a gas directly to a solid. However, the term condensation is used more frequently to describe water vapor changing directly from gas to solid without passing through a liquid state.

Light and Heavy Molecules

Water molecules have less mass than most molecules found in air. When water molecules enter the air they usually displace molecules of greater mass. The mass of atoms and molecules is measured in atomic mass units (amu). Water has 18 atomic mass units. Of the other contents of air, nitrogen (the most common) has 28 atomic mass units, oxygen has 32 and carbon dioxide has 44.

Nearly 175 years ago an Italian scientist named Avogadro discovered that identical containers at the same pressure and temperature have the same number of molecules of gas in them. It does not matter what kind of gas or what mixture of gases is chosen, the number of molecules in each container is the same. A container of moist air has the same number of molecules as an identical container of dry air at the same temperature and pressure, but the mass of the moist-air molecules is less than that of the dry-air molecules. This can be seen by looking at the atomic mass units of the molecules that make up air. Water at 18 amu is the lightest gas in air. Nitrogen (28), oxygen (32) and carbon dioxide (44) are all much heavier. Therefore, air with water in it has a lower mass than dry air.

It is useful to consider the evaporation of water vapor with Avogadro's principle in mind. As water molecules (of less mass) enter the air (consisting of molecules with greater mass), light molecules displace heavier molecules, molecule for molecule. The heavier air molecules tend to settle; the lighter water molecules tend to rise. The resulting air circulation leads to weather changes.

STUDENT WORKSHEET ANSWERS

I.
1 - False
2 - True
3 - False
4 - False
5 - True
6 - True
7 - True
8 - True
9 - True
10 - True

II.
1 - energy or heat
2 - oceans
3 - sublimation
4 - dissolved
5 - fuels
6 - energy,energy
7 - greater
8 - condenses
9 - molecules
10 - rain,snow
11 - seventy
12 - cold,warm
13 - transpiration

GLOSSARY

atomic mass unit (amu): A unit used to measure the mass of atoms and molecules.

condensation: The process of changing from a gas to a liquid or a gas to a solid.

evaporation: The process of changing from a liquid to a gas.

sublimation: The process of changing from a solid to a gas without going through the liquid state.

transpiration: The passage of water vapor from plants to the air.

water vapor: A gas that results from the evaporation of water.

RESOURCES

Books

Alth, Charlotte and Max: DISASTROUS HURRICANES AND TORNADOES, Franklin Watts, New York, 1981

Ardley, Neil: WORKING WITH WATER, Franklin Watts, New York, 1983

Arnov, Boris: WATER: EXPERIMENTS TO UNDERSTAND IT, Lothrop, New York, 1980

Aylesworth, Thomas G. STORM ALERT: UNDERSTANDING WEATHER DISASTERS, Messenger, New York, 1980

Davis, Hubert: A JANUARY FOG WILL FREEZE A HOG, AND OTHER WEATHER FOLKLORE, Crown, New York, 1977

Kwitz, Mary DeBall: WHEN IT RAINS, Follett, Chicago, 1974

Films

CONVECTIVE CLOUDS, Meteorological Society Film Series, Ward's Natural Science, Rochester, N.Y. (27 minutes)

A STORY OF A STORM, Coronet Films, Chicago, IL (11 minutes)

THE WATER CYCLE, Encyclopedia Britannica Films, Chicago, IL (14 minutes)

WEATHER - UNDERSTANDING PRECIPITATION, Coronet Films, Chicago, IL (11 minutes)

WHAT MAKES CLOUDS, Encyclopedia Britannica Films, Chicago, IL (19 minutes)

Software

WATER POLLUTION, E.M.E, Post Office Box 17, Pelham, N.Y., 1985

Name_____ Student Worksheet I

WATER IN THE AIR

True or false. Circle the T if you think the answer is true. Circle the F if you think the answer is false.

T F 1. The water cycle involves evaporation only.

T F 2. Energy is required for something to evaporate.

T F 3. Water vapor carries dissolved substances in it.

T F 4. A certain volume of moist air is heavier than an equal volume of dry air.

T F 5. As water evaporates, the body of water from which it evaporates is cooled.

T F 6. The largest source of water vapor in the air is evaporation from the oceans.

T F 7. If you pour equal amounts of water into two containers, the water in the container with the larger surface area should evaporate quicker.

T F 8. Energy must be removed from water vapor for it to condense.

T F 9. Avagadro discovered that identical containers of any gases at the same temperature and pressure have the same number of molecules of any gas in them.

T F 10. Water vapor is released by the green leaves of trees.

Name_____ Student Worksheet II

WATER IN THE AIR

Fill in the blanks using the following words:

cold	fuels	oceans	sublimation
condenses	greater	rain	transpiration
dissolved	heat	seventy	warm
energy	molecules	snow	

1. Water needs_____to evaporate and become water vapor.

2. Water vapor is always entering the air from the_____.

3. The process of_____involves a solid becoming a gas without becoming a liquid.

4. Water vapor does not carry any_____substances in it.

5. The burning of_____is a source of water vapor.

6. Evaporation is a process that absorbs_____and condensation is a process that releases_____.

7. Most of the molecules in air have_____mass than water molecules.

8. As water vapor loses energy it_____to liquid water.

9. Identical containers at the same temperature and pressure have the same number of_____of a gas in them.

10. Water vapor in the air may return to the earth in the form of_____ and_____.

11. _____percent of the earth's surface is covered by oceans.

12. _____air cannot hold as much water vapor as_____air.

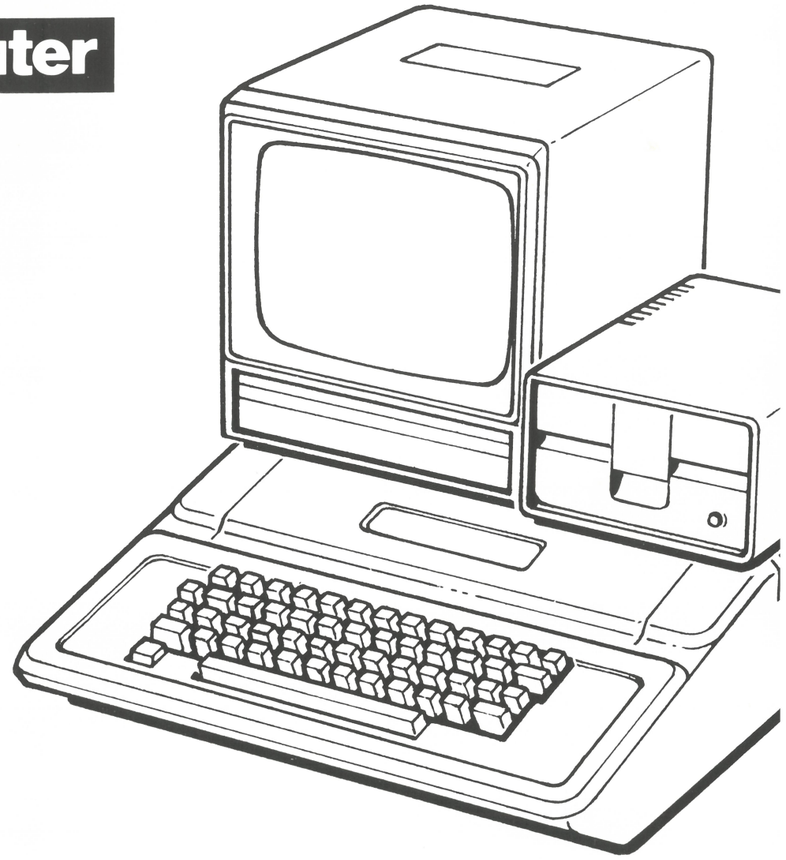
13. Leaves of plants release water vapor in a process called_____.

TEXTBOOK CORRELATION GUIDE

Addison Wesley	
Science	Book 6, Chapter 2
Coronado	
Science & Technology	Book 4, Unit 1, Chapter 2
	Book 5, Unit 2, Chapter 7
Harcourt Brace	
Science	Book 4, Unit 5, Chapters 1-6
Heath	
Science	Book 3, Unit 2, Chapter 4
	Book 4, Unit 2, Chapter 5
	Book 5, Unit 2, Chapter 3
Holt	
Elementary Science	Book 4, Unit 3, Chapter 10
Laidlaw	
Exploring Science	Book 4, Unit 5, Chapters 1,2
Merrill	
Accent on Science	Book 1, Chapter 5
	Book 3, Unit 4, Chapters, 1,3
	Book 5, Unit 3, Chapter 1
Scott Foresman	
Science	Book 4, Unit 2, Chapters 3,4
Silver Burdett	
Science	Book 1, Unit 9
	Book 2, Unit 7
	Book 3, Unit 3, Chapter 11
	Book 4, Unit 3, Chapter 11
	Book 5, Unit 3, Chapter 11

E.M.E

microcomputer program



ELECTRIC CIRCUITS

STUDY GUIDE

by

Frank R. Salamon
Wesleyan University
Middletown, Connecticut

Co-Author
Addison Wesley Science Series

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OVERVIEW

The E.M.E ELECTRIC CIRCUITS program will help middle and upper grade elementary students understand basic concepts of electricity and solve problems dealing with simple circuits. The program consists of two parts:

1. Explanation -- introduces the basic elements of a circuit: cells, terminals, switches, wire and bulb structure. Describes how a circuit is made; open, closed and short circuits; conductors and insulators. A convenient forward/backward feature allows review at any point.

2. Quiz -- consists of two sections each with 20 randomly-selected questions. Quiz score is given at the end of each part.

   A. Simple Circuits: tests student understanding by having them determine whether or not a bulb in a diagrammed circuit will "light".

   B. Conductors and Insulators: with a conductor or insulator in the circuit, students must again decide whether or not the bulb will "light".

After studying the Explanation section of the program students will be ready to build simple circuits on their own and to solve the problems found in the Quiz sections of the program.

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OBJECTIVES

The following concepts are developed in the program:

1. Electric current can travel in a circuit that is closed.
2. A switch is a device which opens or closes a circuit.
3. A short circuit is a circuit in which electricity follows a lower-resistance path that bypasses a bulb or other device presenting greater resistance.
4. Conductors are materials through which current can travel easily.
5. Insulators are materials through which current has difficulty traveling.
6. Energy can be changed from one form to another.

After using this program students will be able to:

1. Recognize and build closed, open and short circuits.
2. Describe the function of a switch in a circuit.
3. Tell if closing a switch in a given circuit will cause the bulb (lamp) to light or not and explain why.
4. Test materials to find out whether they are insulators or conductors.

USING THE PROGRAM

The E.M.E ELECTRIC CIRCUITS program is easy to use and is under your control at all times. The program loads automatically and is ready to use immediately. We suggest that students start with the Explanation section. This provides the background needed to understand electric circuits and to answer the questions in the Quiz sections. The program is designed for Grades 4 and up. When using Apple IIe or IIc, be sure CAPS LOCK key remains down.

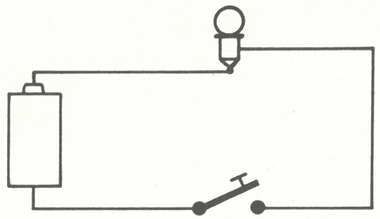
You may wish to assign as your representative at the computer a student who has already taken the quiz to record the scores of other students taking the quiz. The Quiz sections of ELECTRIC CIRCUITS may also be used as an evaluation instrument by teachers who have completed a unit on electricity.

BACKGROUND

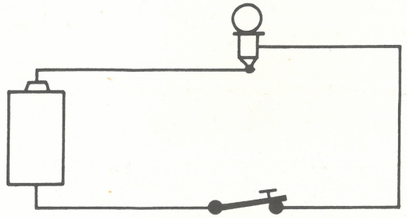
SAFETY NOTE: The activities illustrated in this program use current generated by a D-Cell (common flashlight battery) which does not have any electricity in it. It produces an electric current by chemical action when wires are connected to it in a circuit. Caution children NEVER to use household current to do any of the experiments presented in the program.

A circuit is the pathway a current travels. A switch is used to open or close a circuit. It operates like a drawbridge. When the bridge (switch) is open the

traffic (electricity) cannot travel across it but when the bridge (switch) is closed it can.

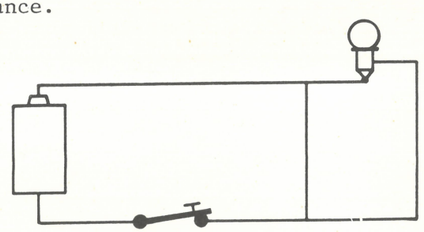


OPEN CIRCUIT



CLOSED CIRCUIT

There is another kind of circuit covered in the program -- the short circuit. A short circuit is created when the current bypasses most of the resistance in the circuit. (A bulb in a circuit may be considered the resistance, as may a doorbell or any other device which works on electricity.) In a short circuit the current takes the path of least resistance.

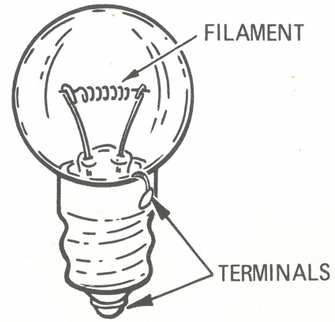


SHORT CIRCUIT

In this case the path of least resistance bypasses the bulb. The wire becomes hot and the battery runs down. Short circuits are dangerous in homes and other locations because wires may become hot enough to start a fire. Fuses and circuit breakers are switches that shut off the electricity when a circuit is overloaded. They protect homes, cars and buildings from electrical fires.

Materials that allow current to travel easily in a circuit are called conductors and are usually metal. For example, copper is an excellent conductor of electricity. Materials that do not readily conduct electricity are called insulators. Glass, rubber and wood are examples.

A bulb has two terminals through which the current flows. The terminals are connected by a filament "bridge" usually made of fine tungsten wire which has a high electrical resistance and does not melt at high temperatures. A tungsten filament converts electrical energy to light and heat energy.



In a bulb ordinary air is replaced by nitrogen and argon gases because they do not react with tungsten, thus increasing the life of the bulb's filament.

GLOSSARY

cell: A device that generates electricity by chemical action.

circuit: A path capable of carrying electric current.

conductor: Matter through which electric current will travel easily in a closed circuit. Examples are most metals, including copper and iron.

filament: Fine metallic wire in a bulb which is heated by an electric current to produce light.

insulator: Matter through which electric current has difficulty traveling. Examples are most non-metals including wood, rubber and glass.

open circuit: A circuit with a gap that prevents electric current from traveling.

resistance: The opposition that a substance offers to the flow of electric current.

short circuit: A circuit in which electric current takes a path of low resistance.

switch: A device used to open or close an electric circuit.

terminal: The point at which an electric circuit connection is made. Batteries and bulbs each have two terminals.

This program uses a high-speed operating system called Diversi - DOS (tm) under license. For information contact DSR, Inc., 34880 Bunker Hill, Farmington MI 48018.

RESOURCES

Ardley, Neil: DISCOVERING ELECTRICITY, Franklin Watts, New York, 1984.

Epstein, Samuel and Epstein, Beryl: THE FIRST BOOK OF ELECTRICITY, Franklin Watts, New York, 1977.

Math, Irwin: WIRES AND WATTS: UNDERSTANDING AND USING ELECTRICITY, Scribner, New York, 1981.

Shapp, Martha and Shapp, Charles: LET'S FIND OUT ABOUT ELECTRICITY, Franklin Watts, New York, 1975.

Wade, Harlan: A BOOK ABOUT ELECTRICITY, Raintree, Milwaukee, 1979.

STUDENT WORKSHEET ANSWERS

1. Conductors: copper, iron, zinc, aluminum, silver
   Insulators: silk, wood, glass, plastic, crayon, rubber, paper

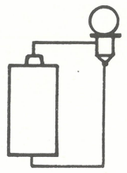
2. two

3. Tungsten is used as the filament because of its high electrical resistance and high melting point.

4. switch

5.

A.



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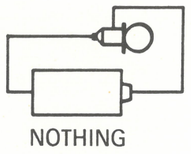

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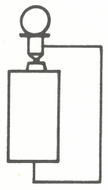

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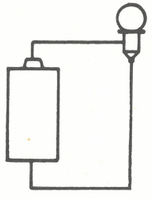

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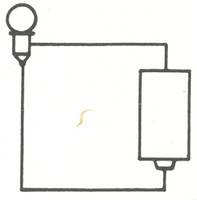


Name_____ Student Worksheet

ELECTRIC CIRCUITS

1. Write a C next to each substance that is a good conductor of electricity and an I next to each insulator.

_____copper	_____iron	_____glass	_____rubber
_____silk	_____zinc	_____plastic	_____paper
_____wood	_____aluminum	_____crayon	_____silver

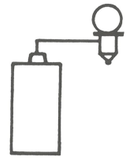
2. How many terminals does a light bulb have?_____

3. What is tungsten used for in a light bulb?_____Why?

4. A device that opens or closes an electric circuit is called a _____.

5. Complete the diagram or write a description of what, if anything, must be done to light the bulb in each circuit below.

A.



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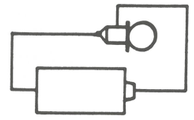

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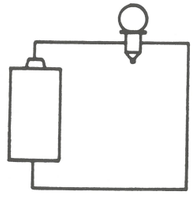

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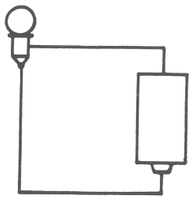

TEXTBOOK CORRELATION GUIDE

Addison Wesley	
Science	Book 4, Chapter 3 Book 6, Chapter 5
Coronado	
Science & Technology	Book 3, Unit 3, Chapter 10 Book 6, Unit 4, Chapter 19
Harcourt Brace	
Science	Book 3, Unit 5, Chapter 3 Book 6, Unit 4, Chapters 1-4
Heath	
Science	Book 3, Unit 3, Chapter 8
Holt	
Elementary Science	Book 3, Unit 4, Chapter 8 Book 5, Unit 6, Chapter 17
Laidlaw	
Exploring Science	Book 5, Unit 3, Chapters 1,2 Book 6, Unit 4, Chapter 1
Merrill	
Accent on Science	Book 4, Unit 8, Chapters 2,3 Book 6, Unit 8, Chapter 1
Scott Foresman	
Science	Book 3, Chapter 6 Book 6, Chapter 13
Silver Burdett	
Science	Book 4, Unit 2, Chapter 8 Book 5, Unit 2, Chapter 7 Book 6, Unit 2, Chapter 8

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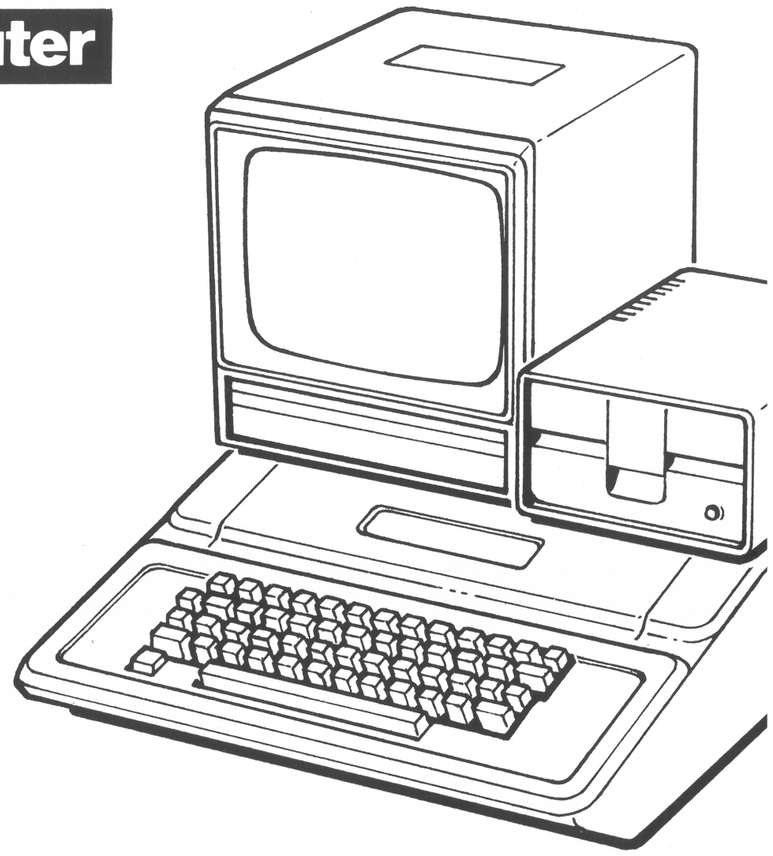

WATER POLLUTION

Programmed

by

Michael Harmon

Irvington High School
Irvington, New York

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EDUCATIONAL MATERIALS AND EQUIPMENT COMPANY

POST OFFICE BOX 17 • PELHAM, N. Y. 10803

OVERVIEW

WATER POLLUTION is an interactive computer simulation consisting of two parts:

1. Introduction -- reviews the basics of water pollution including physical properties of water, factors affecting dissolved oxygen levels, types of water pollution, fish-kills, biochemical oxygen demand, primary and secondary water treatment.

2. Experiment Mode -- setting up and running water pollution experiments.

In the Experiment Mode, students manipulate the variables which influence water quality. Results are displayed in tables and graphs. A student lab booklet provides basic activities to acquaint all students with various aspects of water pollution, as well as advanced activities to challenge brighter students. If possible, run the program in advance to see what your students will encounter. Prior coverage of water pollution topics reviewed in the program's introduction is recommended.

The E.M.E WATER POLLUTION Program is copyrighted and may not be reproduced, stored in a retrieval system or transmitted by any means without prior written permission of the publisher.

OBJECTIVES

The WATER POLLUTION Program will help students to:

1. understand the variables that improve and degrade water quality
2. determine the impact of water pollution on aquatic populations
3. predict the effects of manipulating one or more variables
4. improve data interpretation, problem-solving skills and graphing skills
5. evaluate hypotheses in light of experimental results
6. design experiments and plan a research project

BACKGROUND

Water is a most precious resource. Living things, themselves about 70% water, depend upon water as a medium and reactant for biochemical reactions, for support and for

circulation. In addition, humans use this natural resource for industrial and home use, sanitation, agriculture, recreation and to produce power.

Water is a stable molecule composed of two atoms of hydrogen to every one atom of oxygen. At sea level it vaporizes at 100°C (212°F) and freezes at 0°C (32°F). Water is most dense at 4°C (39.2°F). During the spring and fall, as water approaches this temperature, it displaces water at lower levels. This mixes the body of water, aerating it and bringing nutrients to the surface. In the winter colder but less dense ice forms at the surface protecting organisms overwintering in the bottom waters.

Many useful substances such as oxygen, carbon dioxide and minerals, as well as potentially harmful industrial chemicals and pesticides, dissolve in water. Dissolved oxygen in water results from the photosynthesis reaction in aquatic plants as well as water-surface/atmosphere interactions. Generally, the more turbulent the water, the more dissolved oxygen it can capture from the atmosphere. Cooler water temperatures also increase the levels of dissolved oxygen in a body of water.

Dissolved oxygen levels are also dependent on the rate of decomposition of organic material. As bacteria break organic material into a stable, inorganic form, they use up dissolved oxygen. The amount of oxygen needed for decomposition is called the Biochemical Oxygen Demand (BOD) and is used as an indicator of the "health" of a body of water. A high BOD indicates a high level of organic matter and an "unhealthy" condition. When dissolved oxygen levels become very low, decomposition may occur anaerobically (without oxygen). Noxious gases such as hydrogen sulfide and methane, as well as a foul appearance are characteristic of this condition.

Humans use waterways for disposal of their sewage and industrial wastes, generally reducing dissolved oxygen levels. As the levels approach 5 ppm at about 10°C (50°F), most game fish begin to suffer respiratory distress. Fish will tend to increase their respiratory rate (using up dissolved O_2 faster), while getting 5-10% less

oxygen as water passes through their gills at the faster rate. When dissolved oxygen levels drop below 5 ppm a fishkill results.

Water treatments are used to keep BOD levels low and dissolved oxygen at levels adequate to support aquatic communities. Primary water treatment involves passing water through a coarse screen, a grit chamber and a sedimentation tank to remove heavy, solid waste. This process alone reduces BOD by 35-40%. Secondary water treatment destroys harmful organisms and removes some dissolved materials. This can be done in one of two ways. The Trickling Filter Method passes water over crushed stone (1.5m deep), which captures a film of microorganisms. The film combines with oxygen and changes harmful substances into a form that can be filtered out in a sedimentation tank. Addition of chlorine further purifies the water. Remaining sludge is treated and can be recycled as fertilizer, but more frequently is dumped into the ocean. The Activated Sludge Method of secondary water treatment uses bacteria which, together with oxygen, destroys harmful microorganisms. Primary and secondary treatment combined can reduce BOD by 80-90%.

EXPERIMENTAL VARIABLES

The WATER POLLUTION Program calculates dissolved oxygen and waste concentration levels under a variety of conditions. The model displays results by means of a data table and a graph that plots both dissolved oxygen levels and waste concentration against time.

Students can manipulate the following variables:

1. Body of water (Pond,Lake,Slow or Fast Rivers)
2. Water temperature (1^{o}- 32^{o}C)
3. Type of Waste (Industrial,Sewage)
4. Dumping rate (0-14 ppm/day)
5. Type of treatment (None,Primary,Secondary)
6. Number of days (2 - 30)

To change a variable: Type 1 (Modify Specs) and press RETURN. The computer shows the previous set of data used and displays each variable one at a time to allow for

modifications. To change a variable, type in the new value and press RETURN. To keep a value, just type RETURN.

To return to the Specifications and Options Index: Press RETURN if at the end of a run. Otherwise press CONTROL and RESET simultaneously and type RUN. The Specifications will display the value of each variable from the previous run. The Options Index, also displayed, allows the student to select any of the following forms of output: display table, display plot, or print table.

OUTPUT OPTIONS

To see table of waste concentration and dissolved oxygen levels for each day: Type 2 (Display Table) and press RETURN. Levels are indicated in parts per million (ppm). When dissolved oxygen levels are less than 5 ppm, FISHKILL is flashed on the screen.

To see graphs plotting dissolved oxygen level and waste concentration vs. days: Type 3 (Display Plot) and press RETURN. The computer plots the dissolved oxygen level in red using the left vertical axis and the waste level in blue using the right vertical axis. Variable values for body of water, temperature, dumping rate, type of waste and treatment are listed above graph.

To obtain hard copy output of the data: Type 4 (Print Table) and press RETURN. If a printer is attached, this option prints a paper copy of the data table. (Note: Before executing this option, the program asks if a printer is attached. If Y is entered, the program asks for the slot number -- normally 1 -- where the printer is attached. Enter the slot number to start the printer output.)

To end a session: Return to the Options Index, type 6 (Quit) and press RETURN. The computer gives a goodbye message and offers the option to return to the Introduction or the Experiment Mode. If finished, remove the diskette from the disc drive and turn off power.

To restart the program: If there is a delay of more than 30 seconds, press CONTROL and C at the same time, then type PR #6 and press RETURN. If this fails turn off power, wait 3 seconds and then turn power on again.

STUDENT ACTIVITIES

1. Testing Water Samples for Dissolved Oxygen Levels

Methylene blue is an indicator which changes water color from a deep blue in an oxygen-rich environment to colorless in an oxygen-poor environment. Collect a small bottle of mid-depth water from several local waterways (pond, river, stream, bay or lake). DO NOT COLLECT SEWAGE WATER, as it can be a source of disease. Pour 10ml of each water sample into separate test tubes and mix well with 2ml of methylene blue. Use a stopwatch to record the length of time required to produce a color change. Repeat this procedure for each sample. Compare results for each site.

A) How long does it take for a color change to occur in each sample?

B) Which sample has the highest level of dissolved oxygen? How do you know?

C) Which sample has the highest BOD? How do you know?

2. Effects of Temperature and Dissolved Oxygen on Fish Respiratory Rates

Hardy, freshwater tropical fish, such as large swordtails, angelfish or platys, can be used for this experiment. The optimum temperature for freshwater tropical fish is between 22°C (72°F) and 27°C (80°F). As temperature increases, the amount of dissolved oxygen that the water can hold decreases. Fish attempt to compensate for the lower amount of dissolved oxygen by increasing their respiratory rate. Locate the gill covers of your fish, just in front of the pectoral fins. Count the number of movements of the gill covers per minute (use 15-second intervals and multiply by 4) at the following temperatures: 18°C (65°F), 21°C (70°F), 24°C (75°F), 27°C (80°F), 29°C (85°F). (NOTE: Slowly manipulate the temperature of the fish container over a 15-minute period to achieve the desired temperature. Sudden temperature changes may produce shock and kill the fish.) Perform this test at each temperature at least three times and then average your results for accuracy. Graph the number of gill movements against temperature. What trends in respiratory rate can you notice?

3. Local Investigations

Locate sources of industrial, agricultural or sewage water pollution in your area. Find out how much of each type of waste must be dealt with daily and the problems it presents. Determine how local authorities regulate water pollution and how they enforce these regulations.

4. Arrange a Tour of the Local Sewage Treatment Plant

Collect first-hand information on primary and secondary water treatment technology. Prepare a report summarizing your findings.

GLOSSARY

Biochemical Oxygen Demand (BOD): the amount of oxygen required in a body of water to decompose its organic waste content.

Decomposition: the biochemical breakdown of organic materials into stable, inorganic compounds by bacteria and fungi. This process may be done aerobically (with oxygen) or anaerobically (without oxygen).

Fishkill: less than 5 ppm of dissolved oxygen at 10°C (50°F) results in the death of large numbers of game fish such as trout.

Industrial waste: from factories, mines, research facilities, etc.; includes salts, acids, oils, tars, greases and heavy metals.

Pollution: the undesirable alteration of the environment through human activities.

Primary Waste Treatment: removes heavy, solid waste materials through filtering; this process reduces the BOD by 35-40%.

Secondary Waste Treatment: destroys harmful microorganisms and removes certain dissolved materials by means of bacterial action. Reduces BOD by 80-90% when coupled with primary waste treatment.

Sewage: organic plant, animal, and human wastes.

Sludge: semiliquid waste resulting from sewage purification.

Solubility: the ability to dissolve.

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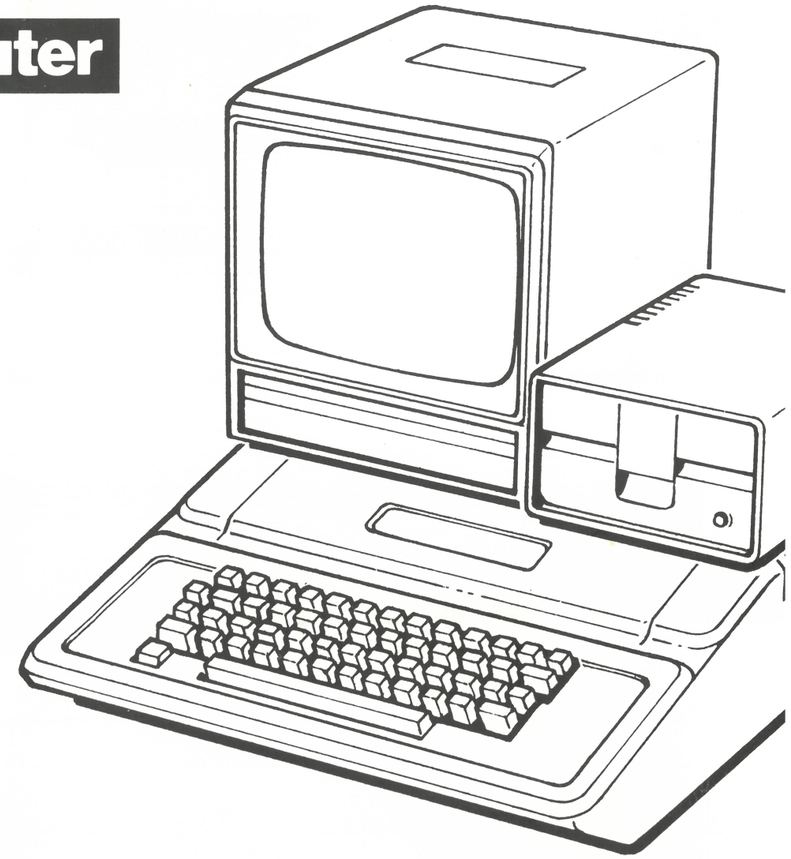

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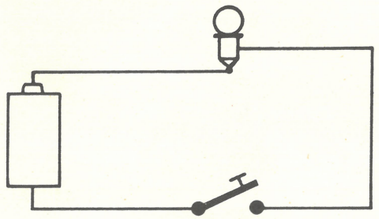
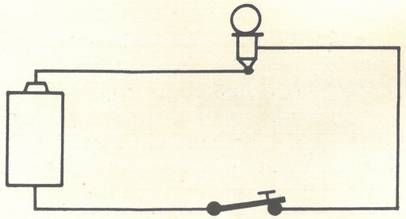
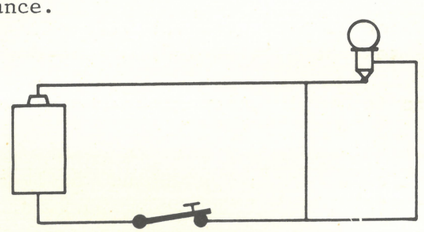


OPEN CIRCUIT



CLOSED CIRCUIT

There is another kind of circuit covered in the program -- the short circuit. A short circuit is created when the current bypasses most of the resistance in the circuit. (A bulb in a circuit may be considered the resistance, as may a doorbell or any other device which works on electricity.) In a short circuit the current takes the path of least resistance.

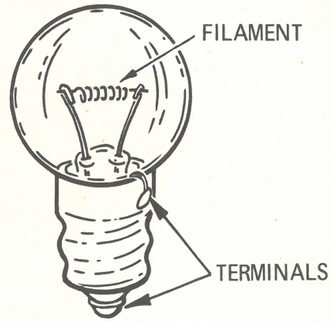


SHORT CIRCUIT

In this case the path of least resistance bypasses the bulb. The wire becomes hot and the battery runs down. Short circuits are dangerous in homes and other locations because wires may become hot enough to start a fire. Fuses and circuit breakers are switches that shut off the electricity when a circuit is overloaded. They protect homes, cars and buildings from electrical fires.

Materials that allow current to travel easily in a circuit are called conductors and are usually metal. For example, copper is an excellent conductor of electricity. Materials that do not readily conduct electricity are called insulators. Glass, rubber and wood are examples.

A bulb has two terminals through which the current flows. The terminals are connected by a filament "bridge" usually made of fine tungsten wire which has a high electrical resistance and does not melt at high temperatures. A tungsten filament converts electrical energy to light and heat energy.



In a bulb ordinary air is replaced by nitrogen and argon gases because they do not react with tungsten, thus increasing the life of the bulb's filament.

GLOSSARY

cell: A device that generates electricity by chemical action.

circuit: A path capable of carrying electric current.

conductor: Matter through which electric current will travel easily in a closed circuit. Examples are most metals, including copper and iron.

filament: Fine metallic wire in a bulb which is heated by an electric current to produce light.

insulator: Matter through which electric current has difficulty traveling. Examples are most non-metals including wood, rubber and glass.

open circuit: A circuit with a gap that prevents electric current from traveling.

resistance: The opposition that a substance offers to the flow of electric current.

short circuit: A circuit in which electric current takes a path of low resistance.

switch: A device used to open or close an electric circuit.

terminal: The point at which an electric circuit connection is made. Batteries and bulbs each have two terminals.

This program uses a high-speed operating system called Diversi - DOS (tm) under license. For information contact DSR, Inc., 34880 Bunker Hill, Farmington MI 48018.

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STUDENT WORKSHEET ANSWERS

1. Conductors: copper, iron, zinc, aluminum, silver
   Insulators: silk, wood, glass, plastic, crayon, rubber, paper

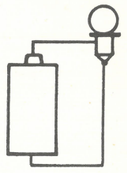
2. two

3. Tungsten is used as the filament because of its high electrical resistance and high melting point.

4. switch

5.

A.



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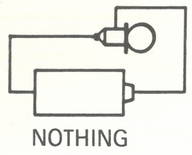

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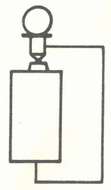

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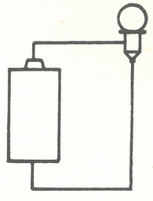

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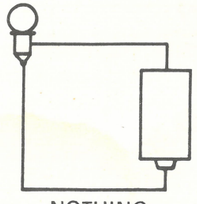


Name_____ Student Worksheet

ELECTRIC CIRCUITS

1. Write a C next to each substance that is a good conductor of electricity and an I next to each insulator.

_____copper	_____iron	_____glass	_____rubber
_____silk	_____zinc	_____plastic	_____paper
_____wood	_____aluminum	_____crayon	_____silver

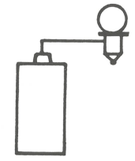
2. How many terminals does a light bulb have?_____

3. What is tungsten used for in a light bulb?_____Why?

4. A device that opens or closes an electric circuit is called a _____.

5. Complete the diagram or write a description of what, if anything, must be done to light the bulb in each circuit below.

A.



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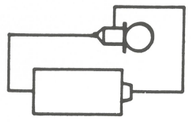
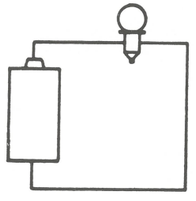


C.

D.



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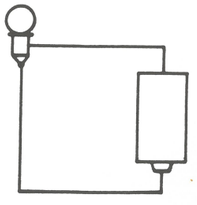
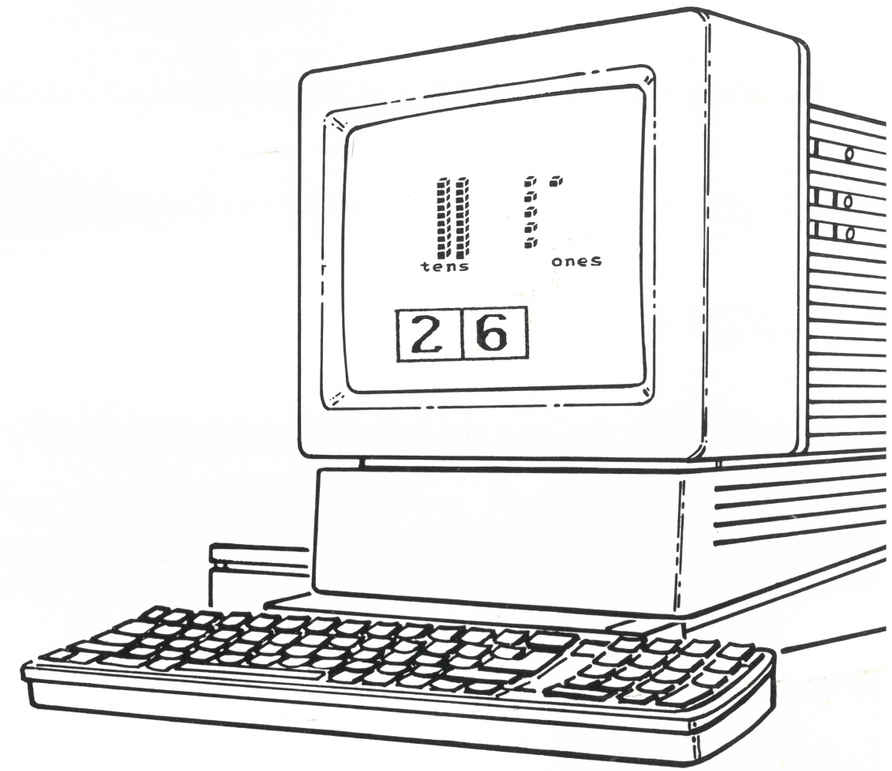


TEXTBOOK CORRELATION GUIDE

Addison Wesley	
Science	Book 4, Chapter 3 Book 6, Chapter 5
Coronado	
Science & Technology	Book 3, Unit 3, Chapter 10 Book 6, Unit 4, Chapter 19
Harcourt Brace	
Science	Book 3, Unit 5, Chapter 3 Book 6, Unit 4, Chapters 1-4
Heath	
Science	Book 3, Unit 3, Chapter 8
Holt	
Elementary Science	Book 3, Unit 4, Chapter 8 Book 5, Unit 6, Chapter 17
Laidlaw	
Exploring Science	Book 5, Unit 3, Chapters 1,2 Book 6, Unit 4, Chapter 1
Merrill	
Accent on Science	Book 4, Unit 8, Chapters 2,3 Book 6, Unit 8, Chapter 1
Scott Foresman	
Science	Book 3, Chapter 6 Book 6, Chapter 13
Silver Burdett	
Science	Book 4, Unit 2, Chapter 8 Book 5, Unit 2, Chapter 7 Book 6, Unit 2, Chapter 8

EME



PLACE VALUE

STUDY GUIDE

by

George H. Ropes, Ed.D.
Mathematics Consultant
Rippowam Cisqua School
Bedford, New York
and
New Canaan Country School
New Canaan, Connecticut

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EME Old Mill Plain Road • Post Office Box 2805
Danbury, Connecticut 06813-2805

OVERVIEW

The E.M.E PLACE VALUE program consists of two parts:

Part 1 gives students an in-depth familiarity with the concept of place value, one of the cornerstones of our numeration system. It provides extensive practice and experience with numbers up to three digits, using three modes of representation: blocks, numerals and words. A convenient forward-backward feature allows review.

Part 2 is Cube Trader, an exciting game offering a wealth of opportunities to manipulate numbers and use place value. It may be played by 1, 2 or 3 students.

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OBJECTIVES

PLACE VALUE will help students to:

1. Increase their knowledge of and familiarity with our basic system of numeration.
2. Write the numeral representing a given quantity of blocks.
3. Show in blocks the equivalent of a number written in numerals or written in words.
4. State the number of 1s, 10s and 100s in numbers represented by blocks, by numerals and by words.
5. Make a block representation of and write the numeral corresponding to a given number of 1s, 10s, and 100s.
6. Become adept at working with the whole number combinations of 10. (1 + 9, 2 + 8....)
7. Increase their enjoyment of arithmetic.

BACKGROUND

Our numeration system is a place-value system -- that is, the value of a digit depends on where it appears in a numeral. As adults, we think in place-value terms automatically. We know the 3 in 348 stands for 300, the 3 in 438 means 30, and the 3 in 123 is just 3. It is easy to underestimate the difficulty children have in acquiring the familiarity we take for granted.

An encounter with Roman numerals makes us appreciate the difficulties of a system that uses place value only minimally. Consider the Roman numeral for 348:

CCCXLVIII

The three Cs are the equivalent of the 3 in 348; the XL (50 take away 10) of the 4; and the VIII of the 8. Compared with our decimal numeration system, writing the Roman numeral is difficult, decoding it is more difficult and doing multiplication or division is extremely complex.

Mathematics educators generally agree that manipulative materials are the foremost tool for teaching place value. A great variety of blocks has been used with varying degrees of effectiveness. A problem with some types of blocks is inflexibility. A 10-stick is permanently a 10-stick; a 100-block is permanently a 100-block.

A computer has the ability to represent 10-sticks and 100-blocks in such a way that they can readily be rearranged into their components. A 10-stick becomes 10 ones; a 100-block becomes either ten 10-sticks or 100 ones and vice versa.

The program PLACE VALUE should be viewed not as a replacement for manipulative materials in the teaching of place value, but rather as a valuable adjunct. It is outstanding in its ability to present and interrelate the three different ways numbers are seen by young children -- as numerals, in words, and as represented by physical objects (blocks or counters).

PART 1 - PLACE VALUE

All students should start with Part 1. This ensures that they have both exposure to and practice with place-value concepts. A student should be able to go through Part 1 with a minimum of difficulty before going on to Cube Trader. The game will then be more meaningful and enjoyable.

At the beginning of Part 1, numbers are in the two-digit range. Three-digit numbers are used later in Part 1 and in Cube Trader. The program is designed for Grades 2

and up. When using an Apple IIe or IIc, be sure CAPS LOCK key remains down.

Throughout Part 1, a student may ask the program to "translate" a number written in numerals or words into its representation by blocks. This is done by pressing the "P" key. It can be invaluable to students who have difficulty understanding the symbols used for numbers.

If certain students become so expert at the place value exercises in Part 1 that further repetition is pointless, they can move to the game from the starting Menu by pressing the numeral 2.

PART 2 - THE CUBE TRADER GAME

Before beginning to play Cube Trader, all students should go through the Instructions section and look at the sample plays. The few minutes so spent will make the game experience far more satisfying.

In Cube Trader, the top of the screen is called the player's "board". The left side is for 100-blocks; the center is for 10-sticks; the right side is the ones pile. Each player tries to be the first to trade for a 100-block. If 2 or 3 players obtain 100-blocks after an equal number of turns, the player with the highest number of cubes is the winner.

On each turn, a random number of cubes (3 - 12) go into the player's Bank. Five different moves are available during each player's turn:

1. Move cubes from the Bank to the ones pile on the board.
2. Move cubes from ones pile to the Bank.
3. Move ten or twenty cubes from the Bank to make one or two 10-sticks on the board.
4. Trade ten 10-sticks on the board for one 100-block.
5. End the turn.

Playing Cube Trader involves both skill and luck. The best move or moves depend on what the player already has on the board and the number of blocks received by the player's Bank.

If the number of cubes in a player's Bank is less than 10, the player must decide "Between the ones in my ones pile and those in the Bank, do I have enough to build the Bank up to 10?" If so, enough ones are moved to the Bank to bring the Bank to 10. Then the 10 ones from the Bank are moved to the 10s pile on the board. This earns a BONUS of 4 cubes.

NOTE: Occasionally, a player can build the number in the Bank up to 20 and make two 10-sticks on the board. This also earns a 4-cube BONUS.

If the number in the Bank is less than 10 and the player does not have enough ones to build it up to 10, the cubes are simply moved from the Bank to the ones pile.

If the number in the Bank is 10, 11 or 12, and the player cannot build the number up to 20, 10 cubes are moved up to become a 10-stick on the board. Any remaining ones are moved to the ones pile.

When a player ends a turn with 10 or more cubes in the ones pile, a 4-cube PENALTY is assessed for failing to make the trade. The 10 ones should have been moved to the Bank and a 10-stick moved to the 10s pile. The same penalty applies if a player ends a turn with ten or more 10-sticks in the 10-pile. They should have been traded for one 100-block.

PROGRAM APPLICATIONS

Learning about place value and practicing with it are valuable for virtually all children in the middle years of elementary school. Some students may go through Part 1 easily. Others will take more time to complete it, but almost all students will find the experience useful. It is likely that students needing remediation in mathematics will be the biggest gainers from exposure to Part 1, whatever their grade

placement may be.

The optimum arrangement for Part 1 is one or two students per computer; three students per computer is possible but not recommended. Fifteen or twenty minutes per session is practical. Encourage students to verbalize to themselves or their partner each step as they manipulate numbers of blocks.

If students have difficulty with either Part 1 or Part 2, encourage them to move actual 100-blocks, 10-sticks and 1-cubes in the same way these are moved on the screen.

The Cube Trader game may be played by 1, 2 or 3 students. With 2 or 3 students there is the challenge of who gets 100 or more cubes first. In the solitaire game, students can be encouraged to set a record for the least number of turns taken to get a 100-block.

ADDITIONAL ACTIVITIES

1. Have students investigate ancient numeration systems such as Babylonian or Mayan and report on how place value was handled in each.

2. Provide as much opportunity as possible for students to represent and work with numbers through manipulative materials, such as:

   Blocks that represent 100s, 10s and 1s
   Interlocking cubes
   Coins (dimes and pennies; or quarters, nickels and pennies)
   Colored chips
   Tongue depressors (some as 1s, some banded into 10s and 100s)

3. Familiarize students with the use of the abacus and other devices where columns represent different place values.

4. Advanced students may enjoy working with number systems based on 2, 5 or another non-decimal base.

GLOSSARY

decimal: Based on the number 10.

digit: One of the numbers from 0 through 9.

number: The aspect of a group that can be counted.

numeral: A figure or character, or group of either, used to express a number. Examples: 2, 14, 237.

place value: The value of digits as determined by their position in numbers.

quantity: Total amount or number.

symbol for a number: A conventional sign used to represent a number.

written number: A number named with words. Examples: forty, sixty-seven.

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Shookoohi, Gholam-Hossein: Manipulative Devices for Teaching Place Value, ARITHMETIC TEACHER, Mar. 1978, pp. 49-51

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